TUBERCULOSIS AND NATIONAL HEALTH

BY THE SAME AUTHOR

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TUBERCULOSIS AND NATIONAL HEALTH

by

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TO
MY WIFE
EDITH ELLEN

PREFACE

THE aim of this book is to provide a short and concise study of present-day views regarding the problem of Tuberculosis in relation to National Health. During the last twenty years there has emerged a considerable volume of literature on the subject of Tuberculosis which, within recent years, has increasingly dealt with the epidemiological and sociological aspects of the disease.

The writer has endeavoured to clarify his own views on the subject in the light of present-day knowledge and he trusts that the study which he presents in this volume may be of some service to those who, in clinical practice or investigation, are closely associated with the disease and to others who take an interest in the national aspects of the problem.

His best thanks are due to his friend and colleague, Dr. T. N. Kelynack, for revising the proofs and for his helpful advice.

H. HYSLOP THOMSON

Hertford, 1939

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Chapter One

INCIDENCE AND SIGNIFICANCE OF TUBERCULOSIS

TUBERCULOSIS is a disease which has existed from earliest recorded time and it is directly related to the standard of social life. It is practically unknown among primitive people who live under natural changing conditions; they do not suffer from the disease because they are immune, for they are extremely susceptible, but for the reason that they do not come in contact with the pathogenic type of organism which induces infection. When these primitive susceptibles come into touch with civilization and into contact with the human type of the tubercle bacillus they develop acute manifestations of infection which result in a high mortality. One of the interesting yet unsolved problems in connexion with tuberculosis is why under natural conditions of man's existence the tubercle bacillus should be absent or remain avirulent whereas under the conditions associated with community life of an inadequate hygienic standard it becomes parasitic and pathogenic to man.

Tuberculosis was a disease of ancient civilizations, as is proved by written records and archaeological findings. It was prevalent in China long before the Christian Era, and in the older records of that civilization reference is made to 'lung cough and lung fever'. Hall states that clear descriptions of the causes and symptoms of tuberculosis of the lungs appear in the writings of the Ming Dynasty (A.D. 1368–1644). The archaeological investigations of Elliott Smith, Derry, and Ruffer have brought to light the existence of tuberculosis of bones in Egyptian mummies of the periods 3000 B.C., 2500 B.C., and 1000 B.C. Changes suggestive of tuberculous disease of the spine have been found in bones of Nubian origin dating from 3000 B.C. and 2000 B.C.

Tuberculosis of the lungs was well known to the physicians of ancient Greece. Hippocrates (460–377 B.C.) gave an accurate description of its chief symptoms and recognized its association with haemoptysis, fever, and pleurisy. The communicability of

tuberculosis was postulated at this early date by Isocrates, a contemporary of Hippocrates, and subsequently by Aristotle and Galen. Celsus (30 B.C.) recognized pulmonary tuberculosis as a clinical entity and advocated treatment which in broad principles differed little from the conservative treatment of to-day. That tuberculosis was an infectious disease was recognized by Fracastorius (A.D. 1484–1553), who pointed out the risk of infection incurred by contacts; the contagious character of the disease was also recognized by Morton in England in 1689. During the eighteenth century the infectious character of pulmonary tuberculosis had come to be accepted in Italy and in Spain. In 1865 Villemin proved by a series of experiments that the disease could be transmitted from animal to animal and from man to animal. In 1882 Koch crowned a long course of brilliant and painstaking experimental work by the discovery of the tubercle bacillus as the specific causative agent of the disease.

TUBERCULOSIS IN ANIMALS. The question of tuberculosis in man is intimately related to the disease in animals, and many characteristic features of the former are also observed in the latter. One distinctive feature, however, has to be noted. While no race of man appears to possess any marked degree of natural immunity to infection with tubercle bacilli, such immunity to infection, although varying and relative in degree, is observed in certain animals. The horse, the donkey, the sheep, and the mule, although they have for centuries been closely associated with man and with bovines, show a relatively high degree of natural resistance to infection. On the other hand, apes, bovines, pigs, rabbits, guinea-pigs, and certain birds are all susceptible. The disease is stated to be rare among wild animals, although animals of the deer tribe, if they feed on contaminated pasture, become infected. Hamerton states that he has seen no evidence of tuberculosis in the wild horse, ass, or zebra, and that it seldom occurs in camels or kangaroos. From recent evidence, however, it would appear that tuberculosis occurs in animals in the wild state more frequently than is generally supposed. Wells, as a result of an investigation into the character of disease occurring in voles trapped in uncultivated areas in England, Scotland, and Wales, has found that these animals suffer from advanced tuberculosis, and that the caseating lesions which occur in the viscera

contain large numbers of acid-fast bacilli. These bacilli on further investigation have been found to give rise to fatal disease in guinea-pigs but to be non-fatal to rabbits, and the specific character of the organism has been proved by the fact that both these animals after infection reacted to inoculation with tuberculin, although the true type of the bacillus has not yet been determined.

One interesting feature connected with the life of wild voles is to be found in the sudden waves of increase and decrease which occur. The animals increase in such numbers as to constitute an actual plague which results in the devastation of large areas of hill and low-lying pasture and in serious loss to sheep farmers. Plagues of this character have occurred in this country in the south of Scotland and in the Forest of Dean, and in France, Germany and Italy, and they are characterized by a rapid increase, a peak which may last for a year or more, and a sudden decrease. This sudden decrease is stated to be due to the outbreak of epidemic disease and it would be interesting to know in the light of the results of the investigation carried out by Wells whether the mortality were due to the development of tuberculous infection in epidemic form.

Tuberculosis is a disease which occurs in various species of animals, the type of the bacillus for each species having distinctive features. Special types for man, mammals, birds, fish, and other cold-blooded animals have been recognized. Scott, who has made a special study of the subject, gives a detailed account of the pathological changes in animals including those in captivity, produced by the tubercle bacillus. The degree of pathogenicity of the various types of the organism for different animals has been the subject of prolonged and careful investigation.

The human type of the tubercle bacillus is highly virulent to man, apes, and guinea pigs, and less so to rabbits. It is pathogenic to rats, mice, especially field mice, dogs, pigs, and parrots. The ox, horse, goat, sheep, and cat are highly resistant, and cold-blooded animals are immune to infection.

The bovine type of tubercle bacillus is highly virulent to calves, apes, rabbits, guinea-pigs, and goats, and is pathogenic to man, dogs, sheep, pigs, cats, horses, parrots, rats, and mice; cold-blooded animals are resistant.

The avian type of tubercle bacillus is highly virulent to fowls,

pigeons, pheasants, and other birds, but ducks and geese are more resistant; wild birds in captivity may become infected. It is also pathogenic to rats and mice, calves, pigs, sheep, cats, guinea-pigs, and rabbits, but the infection is much less severe: monkeys and apes are generally resistant as are also cold-blooded animals.

The piscian type of bacillus is pathogenic to frogs, turtles, fish, lizards, snakes, and other cold-blooded animals. These animals are not susceptible to the avian or mammalian type of bacillus. No evidence has so far been brought forward to show that the piscian type of bacillus is pathogenic to warm-blooded animals.

Man and the lower animals, especially domestic animals, are also in contact with and must inhale and ingest saprophytic acid-fast bacilli. These bacilli, examples of which are the Timothy-grass bacillus, the Bacillus Butyricum and the Bacillus Stercusis, the latter being found in the faeces of herbivorous animals, are widely distributed in nature. Isolated instances of lesions in animals produced by saprophytic bacilli, which though similar to tuberculous lesions, are non-progressive in character, have been recorded. Saprophytic strains of acid-fast bacilli have also been found in animals. Cooper and Petroff have found acid-fast bacilli in the lymph glands of 33 per cent of apparently normal guinea-pigs, and somewhat similar findings have been obtained by other observers.

The subject of the relationship of the various types of acid-fast organisms to each other and to pathogenicity in the lower animals and in man has yet to be fully elucidated. The trend of the results obtained by some recent investigations inclines one to speculate as to the possibility of the evolutionary development of the tubercle bacillus through various animals to the summation of pathogenicity in man. A possible explanation may also be that the human type of bacillus represents the evolutionary end-result of saprophytic acid-fast bacilli which under natural conditions of life are non-pathogenic, but which through long and close contact with man under altered conditions of life have assumed pathogenic characters.

RACIAL TUBERCULOSIS. The incidence of tuberculosis and the mortality resulting from the disease vary in different races. Whether this variation is due to a variable degree

of natural resistance or depends entirely upon difference in the standard of social conditions and upon the absence or presence of acquired or inherited specific protection has not yet been fully determined. The view generally accepted is that the susceptibility of certain races is due to the absence of the specific protection which is induced by a primary infection, although the fact that a certain proportion of such susceptibles does not develop clinical manifestations of the disease when brought into contact with civilization, points to the possible existence of inherent natural immunity in certain individuals. This also applies to civilized races, but the question of protection and infection is discussed more fully in a subsequent chapter.

The incidence of tuberculosis is more marked in certain parts of the British Isles than in others. Generally the Celtic race appears to be more susceptible than the Saxon, and the geographical distribution of the disease bears this out, although the influence of such factors as housing and industrial conditions have to be taken into account. Bradbury in his report on the Tyneside investigation states that the greater incidence of tuberculosis in Irish than in English families cannot be wholly explained by different environmental conditions, and that there exists evidence of some racial factor which is in part responsible for the relatively high incidence of the disease in the former. The high incidence of the disease in some of the Welsh counties is well known, and in the writer's clinical experience, now some years ago, the young adult type of the disease was definitely more severe and progressive in character in Scotland and in Wales than in the south of England. Brownlee, who has made a special study of the age types of pulmonary tuberculosis, has found that while the young adult type is more frequently met with in coast districts, the middle age type is more prevalent in urban districts from London to the Northern Midlands. As regards European countries the disease is less prevalent in North-Western Europe than in Mid, Eastern, and Southern Europe.

An interesting aspect of the epidemiology of tuberculosis is the relative susceptibility of light-skinned and dark-skinned races apart from the protective influence of previous infection or the adverse influence of insanitary and unhealthy environmental conditions. The problem has been studied extensively in America,

and the general consensus of opinion in that country is that the higher resistance of the white race is due to the protective influence of previous infection supplemented by the beneficial influence of a higher standard of living.

It is well known that in primitive races who live under natural conditions completely detached from contact with civilization tuberculosis is an unknown disease. This is proved by the negative evidence of post-mortem findings, and the negative response to tuberculin tests. Borrel found in 1920 that in only 3 per cent of Senegalese soldiers was a positive tuberculin reaction obtained.

The occurrence of tuberculosis in dark-skinned races follows contact with civilized communities and the incidence of and mortality from the disease increase *pro rata* with the degree of contact. This has been clearly demonstrated by the history of African races and of North American Indians. Recent investigations have also shown that the state of tuberculization is extending somewhat rapidly even among the more remote African natives. Burrows, Matthews, and Wilcocks, in their reports of investigations as to the incidence of tuberculosis and tuberculization among natives in the Bahr-el-Ghazal Province, the Zanzibar Protectorate, and the Tanganyika Territory give the following figures respectively for these three districts. In the Dinka country in which tuberculosis was practically unknown prior to 1905 owing to its extreme isolation, Burrows obtained the following percentage of reactors; total number tested, 3,662; percentage positive, 32·7; positive reactors in age groups—under five, 7·5 per cent, five to ten, 19·6 per cent, ten to twenty-five, 36·1 per cent, over twenty-five, 50·7 per cent. In Zanzibar Town and Zanzibar districts Matthews found the following percentages of positive reactors in two groups of persons. Town: total number tested, 683; positive reactors in age groups—under nine, 48 per cent, ten to nineteen, 66 per cent, twenty to thirty-nine, 71 per cent, forty, 57 per cent. Districts: total number tested, 242—under nine, 14 per cent, ten to nineteen, 28 per cent, twenty to thirty-nine, 50 per cent, forty, 75 per cent. In the Tanganyika Territory, Wilcocks obtained the following results using the Mantoux Test with a dilution of 1 in 500: total number tested, 523: positive reactors in age groups—males: six to fifteen, 47 per

cent, sixteen to twenty-five, 43 per cent, twenty-six to fifty, 60 per cent, over fifty (four in number) 100 per cent. Females: six to fifteen, 55 per cent, sixteen to twenty-five, 33 per cent, twenty-six to fifty, 44 per cent.

In America where the coloured race has lived under similar conditions of life to the white race for a considerable time and where the influence of protective infection should be about equally effective, the difference in the death-rates from the disease is yet marked. Drolet's figures of the mortality rates from tuberculosis for twenty-one American cities for 1933, show that the rate for the negro population is about four times that for the white, although the rate for both continues to fall. The following are the figures of the mortality-rates for a number of cities in the group: Atlanta, white 27, negro 152; Birmingham, white 36, negro 169; Colombus, white 43, negro 230; Chicago, white 48, negro 255; Detroit, white 55, negro 232; Washington, white 57, negro 295; Philadelphia, white 57, negro 201; New York City, white 59, negro 264; Cincinnati, white 59, negro 369; New Orleans, white 71, negro 238; and Los Angeles, white 85, negro 197.

The lowest white death-rate, 27, occurred in Atlanta and the highest, 85, in Los Angeles. The lowest negro death-rate, 127, occurred in Houston, and the highest, 369, in Cincinnati.

In considering the high incidence of tuberculosis among coloured races due regard must be given to the influence of various factors. Social conditions and domiciliary habits in so far as they tend to facilitate the spread of massive infection must necessarily play an important part. The type of the disease as regards rapidity of caseation and the number of tubercle bacilli expelled must also influence its rate of dissemination, although if acuteness of type in coloured races who have some degree of specific resistance be generally more marked than in white, it is a strong argument in favour of some inherent natural susceptibility. Opie has pointed out that various opinions exist regarding the susceptibility of the negro race to tuberculosis. While some authorities believe in the existence of an inherent predisposition to the disease, others attach chief importance to the greater risk of massive infection owing to inferior social and environmental conditions, and to the possibility that the percentage of persons

partially protected by a primary infection in childhood is considerably lower in coloured than in white races.

The contention that the inherent resistance of the black race to tuberculosis is normally below that of the white is supported to some extent by the evidence adduced from a study of the response of patients to sanatorium treatment. Opie refers to the experience of Carter who has found that apart from the type or stage of the disease, improvement in response to treatment is more frequently observed in white than in black people. Carter has also observed in this connexion that mulattos occupy a somewhat intermediate position between whites and blacks.

The existence of a varying degree of inherent susceptibility to tuberculosis in coloured races is also supported by the findings of other observers. Cochrane, who has made a special study of the incidence of tuberculosis among the inhabitants of British Guiana which has a population of 310,000 with Indians and negroes in about equal numbers, gives the following figures for deaths per 100,000, during the decennium 1922–1931: Indian aborigines 110, negroes 140, Portuguese 120, Chinese 90, and East Indians 80. The significant feature of these statistics is the high figure for negroes compared with the other races. Regarding the type of the disease in the latter, Cochrane states that the majority of negroes with tubercle bacilli in the sputum died within fifteen months after the disease had been notified. Wilcocks, who has studied the types of tuberculosis in Tanganyika natives, has found that in the majority of cases the disease is acute and progressive in character, and that fibrosis is rarely observed in the groups under middle life. He is of opinion that the type is intermediate between that seen in primitive races and the more chronic form characteristic of white races.

Arnould has carried out an investigation as to the incidence and type of tuberculosis in negroes from West Africa in whom a secondary infection developed, although the protective influence of a primary infection was present. He found that whereas in whites the secondary infection was of a latent character, a similar infection in negroes was much more severe and rapidly fatal, conforming more closely in type to that observed in unprotected infants. He states that the death-rate in the coloured race from secondary infection is three to five times as high as that in the white,

and after making allowance for the adverse influence of inferior home conditions, he concludes that the evidence supports the view that the inherent resistance of the black race is inferior to that of the white.

The history of the North American Indians has proved their extreme susceptibility to tuberculosis. So long as they kept moving about with their tipi away from white settlements, remaining at and fouling the same place for a short period of time only, they were free from the disease. Immediately, however, they settled down on fixed sites, occupied permanent buildings and came into contact with the white race, they were attacked by the disease which gave rise to a high incidence and mortality. Bushnell gives figures showing the mortality from tuberculosis in four Indian tribes during the year 1918, the death rates per 1,000 being 1·10, 3·08, 6·15, and 7·76, respectively. To illustrate the high mortality from the disease in primitive Indians he quotes figures given by Walker and Brewer. In 1896 among 4,893 Oglala Sioux Indians, many of whom were captives who had previously led a wild, wandering life, the annual death-rate was 25·3 per 1,000, and among the Pimas and Maricopas Indians tuberculosis was responsible for 66 per cent of the deaths. These figures illustrate the fatal ravages of tuberculosis among Red Indians when they are transferred from a wandering existence to a stationary life in contact with civilization. A reduction in the incidence of the disease, however, has followed improved conditions of life; in the reservations tuberculosis is not very prevalent, but it is nearly always fatal owing to the absence of an adequate degree of resistance.

If a special susceptibility to tuberculosis infection on the part of coloured races be postulated it is interesting to speculate on the possible cause of such susceptibility. Is it a question of diet with deficient intake of vitamins and salts, or does a variation in the degree of absorption of solar radiations exercise some influence on the degree of resistance to infection, or lastly is the relatively high resistance of the white race due to an inherent influence arising from centuries of racial tuberculization, with progressive improvement in social conditions?

TUBERCULOSIS AND URBAN CIVILIZATION.

Tuberculosis is a disease which has developed in man consequent

upon his departure from a separate and wandering life and assuming the method of living in fixed communities. It is essentially associated with fixity of domicile, diminished air movement and sunshine and the presence of organic impurities, but the true causal relationship between the virulence of the organism and environmental conditions are as yet unknown. Recent investigations tend to prove that insanitary home conditions, in the absence of infection do not in the brief period of a few years give rise to tuberculosis. A study of the history of the disease however, points to the existence of some influence exercised by insanitary environmental conditions through an extended period upon the pathogenic character of the tubercle bacillus.

The incidence of tuberculosis and the mortality from the disease increase as the standard in the hygienic and sanitary conditions of social life declines, and they reach their peak where density of population, overcrowded houses, indifferent feeding, and insanitation generally are features of urban existence.

Tuberculosis may thus be defined as the morbid expression of conditions of life incompatible with a normal standard of physical health, vigour, and nutrition, and the death-rate from this disease may be accepted as constituting a fairly accurate index of the health standard of an urban or rural community as the conditions of life which are associated with its presence are instrumental in facilitating the development of other forms of disease.

The incidence of tuberculosis is generally higher in urban than in rural districts, where conditions are comparable, but there is evidence that within recent years, associated with decline in the prevalence of the disease, there has occurred a gradual change which has resulted in a closer approximation of the statistics for urban and rural districts. The comparative figures for urban and rural districts in England and Wales are shown in the table on the opposite page.

In this table it will be observed that while the Administrative Counties have the lowest death-rates, the County Boroughs show distinctly higher maximum rates than the Metropolitan Boroughs. The Welsh Counties and Boroughs have not been included, and the effect of their inclusion on the table would be to make the maximum death-rates from both forms of tuberculosis

in the Administrative Counties for both years higher than the rates for the Metropolitan Boroughs, but lower than the rates for County Boroughs.

The highest death-rate from all forms of the disease for County Boroughs and Administrative Counties for the two years occurred in the North of England. The figures for the County Boroughs in Wales for deaths from all forms, though relatively high, are lower than the maximum given in the table. On the other hand, the death-rates in some of the Welsh Counties show figures considerably in excess of the maximum for the English Counties, while the ratio of death-rates from tubercolosis of the respiratory system is high.

Highest and Lowest crude Death rates from Tuberculosis in Metropolitan Boroughs, County Boroughs, and Administrative Counties in England for 1935 and 1936

Tuberculosis		Metropolitan Boroughs		County Boroughs		Administrative Counties	
		1935	*1936*	*1935*	*1936*	*1935*	*1936*
All forms	Highest . .	1,068	1,004	1,429	1,342	819	776
	Lowest . .	419	430	452	471	317	420
Respiratory System	Highest . .	954	938	1,150	1,145	680	688
	Lowest . .	320	353	391	343	243	337

A comparison of the figures for various boroughs and counties clearly shows the trend of the death-rates; it is highest in densely populated, overcrowded, industrialized areas, and lowest in healthy rural areas and in well-spaced urban districts where the standard of living is high and in urban districts it reaches its lowest level in garden cities.

In certain rural areas and in certain administrative counties the death-rate from tuberculosis is higher than in many large urban districts. It will be obvious that as the ratio of protected persons in rural districts is low compared with that in larger urban districts, the tendency will be for the death-rate from the disease to rise in rural districts in proportion to the extent to which contact is established between urban and rural populations. There is no evidence in this country that the death-rate from tuberculosis

in rural districts is remaining stationary or increasing, although the decline must for obvious reasons be less marked than in urban districts. Conversely, there will be a tendency for the death-rate from tuberculosis to rise more sharply in urban than in rural districts if the general hygienic and sanitary standard of the country should be seriously lowered by war, revolution, or serious economic stress. The possible influence of urbanization on the incidence of tuberculosis in rural districts cannot, however, be overlooked. Many rural districts have been completely built over since the War, so that in many counties the ratio of urban population has greatly increased. It is true that a considerable percentage of this moving urban population is partially protected by primary infection; but such protection is not sufficient to eliminate the possibility of the subsequent development of active disease, while closer contact of persons suffering from tuberculosis with the rural population which is less protected will increase the risk of infection.

The effect of adverse social and domiciliary conditions on the incidence of tuberculosis in rural districts emphasizes the aetiological relationship of such conditions to the disease. In many country districts there exist small towns in which density of population and overcrowding favour the spread of tuberculosis once infection has been introduced. Even in hamlets and in more sparsely populated districts the conditions may be such as to encourage a relatively high incidence of the disease. An illustration of this is given in the report of a survey by Hutchison. The parish in which the survey was made had a population of 1,276, with a village of fifty-four houses. The majority of the houses were of the usual rural cottage type with no protective damp-proof course. The windows were small and many of them were not made to be opened, while the rear walls were blind with the consequent absence of through ventilation. Of 275 houses only fifty had drainage, and water was obtained from wells and springs. Wages were low, intermarriage was frequent, and the food was deficient. Tea was taken at every meal and the children had condensed milk. During the period 1875–1914 one-sixth of the total deaths were certified as due to tuberculosis, the death-rate being 2·8 per 1,000.

Reference has been made to the difference in the ratio of

susceptibles in rural as compared with urban districts. The observations of Pirquet, Hamburger, Calmette, and other observers have shown that in large urban districts in Europe approximately 100 per cent of the population above the age of fifteen give a positive tuberculin reaction. In rural districts the percentage of positive reactors is much lower. Rathburn obtained a positive reaction in 25 per cent in a New York State village and Elliott found a percentage of 22 in a rural series.

The present position, therefore, is that while in urban districts the incidence of clinical tuberculosis is higher than in rural districts, the ratio of positive reactors who possess some immunity to fresh infection is also higher in urban districts.

The question of immunity resulting from urbanization, associated with the steadily improving sanitary and industrial standard in urban districts presents a study of importance in relation to the epidemiology of tuberculosis. As the incidence of tuberculosis declines in urban districts and the sanitary standard further improves, the ratio of positive reactors will tend to fall, while that of susceptibles will tend to rise, and a stage will eventually be reached when a considerable percentage of dwellers in large but not overcrowded urban districts will be non-reactors. Under such conditions, should the sanitary conditions and standards of living become altered for the worse owing to some social upheaval and should there be marked movements of population with consequent overcrowding, a sharp rise in the incidence of the disease may be expected. The possibility of some such change is envisaged by D'Arcy Hart, who points out in the Milroy Lectures for 1937 the importance of taking stock of areas and classes of population with a high ratio of adult negative reactors and a low incidence of pulmonary tuberculosis and of other areas and classes where the converse holds as the movements of populations may prove to be of importance from the epidemiological point of view.

INCIDENCE, AND DECLINE IN MORTALITY. There is no guide to an approximate estimate of the actual number of cases of clinical tuberculosis occurring in this country. The ratio of deaths to primary notifications in England and Wales and in Scotland is shown in the following tables.

Primary Notifications and Deaths, all forms of Tuberculosis in England and Wales, 1933–1937

	1933	*1934*	*1935*	*1936*	*1937*
Notifications . .	66,351	64,230	59,623	59,268	59,918
Deaths . . .	33,259	30,882	29,201	28,268	28,529
Ratio: Deaths to Notifications .	1–1·9	1–2·0	1–2·0	1–2·0	1–2·1

Primary Notifications and Deaths, all forms of Tuberculosis in Scotland, 1934–1936

	1934	*1935*	*1936*
Notifications	8,051	7,890	7,755
Deaths	3,704	3,647	3,664
Ratio: Deaths to Notifications . .	1–2·1	1–2·1	1–2·1

The figures of primary notifications are for various reasons of no value as a guide to an accurate estimate of the number of clinical cases of the disease. The varying degrees of infection which occur constituting in some cases a mild clinical form of the disease unrecognized by the patient accentuate the difficulty. It has been estimated that for every death there exist ten cases of clinical tuberculosis, but this is probably an under-estimate, although it may be accepted as a useful figure for reference. As to the incidence of latent disease characterized by living tubercle bacilli in fibrosed foci it is impossible to hazard an estimate. As regards the percentage of positive reactors for the country as a whole it is probable, judging from the figures available, that fifty for urban districts and twenty for rural districts would be a reasonable estimate for the adult population in this country.

One of the features of the incidence of tuberculosis is the progressive fall in the death-rate from the disease which has taken place since the middle of last century, except during the period of the War years when there was a sudden rise. The decline relates to both pulmonary and non-pulmonary forms of the disease, but since the early years of the present century the decline in the death-rate from non-pulmonary tuberculosis has been more rapid.

Standardized Death-rates per Million from Tuberculosis during Decennial and Quinquennial Periods, 1851–1935

(*Registrar-General Statistical Review, 1936*)

Period	Tuberculosis (all forms)	Tuberculosis (respiratory system)
1851–1860	3,478	2,772
1861–1870	3,263	2,590
1871–1880	2,882	2,231
1881–1890	2,444	1,810
1891–1900	2,021	1,418
1901–1905	1,739	1,208
1906–1910	1,556	1,082
1911–1915	1,389	1,005
1916–1920	1,359	1,009
1921–1925	1,065	815
1926–1930	922	721
1931–1935	782	620
1935	687	552
1936	657	525
1937	657	523

A study of the above figures reveals three facts of interest. From the latter half of last century up to the outbreak of war in 1914 there had been a progressive decline in the death-rate from tuberculosis. This decline may be attributed in some measure to increased specific protection, but the main factor regarded as responsible has been the improvement in the sanitary and hygienic standard of living which followed the efforts at public health reform which were a feature of the latter part of last century, and which found expression in the Public Health Act of 1875. Koch held the view that part of this decline in the death-rate from tuberculosis was the result of the removal from their homes of advanced cases of tuberculosis to Poor Law institutions. During the war years there was a check in the decline and an increase in the death-rate from pulmonary tuberculosis, but from the year 1921 the decrease has become more marked than at any other previous period of similar duration. This sharp decline is due not only to a continual improvement in the general standard

of living, but to the intensive measures which have been carried out during recent years with a view to promoting prevention and to securing adequate treatment for those suffering from the disease.

One rather disturbing feature of this decline, however, is that it is not equally pronounced in all the age groups in which the incidence of the disease is most marked. In the young adult female group arrest in the fall of the death-rate during the period 1901–1929 has taken place, which is shown in the following table.

Percentage decline in Mortality from Pulmonary Tuberculosis per 100,000 living at Each Age in Females

	10–15	*15–20*	*20–25*	*25–35*	*35–45*	*45–55*	*55–65*	*65–75*	*75*
Decline per cent 1901 from 1851 to 1860.	69	72	70	64	56	52	53	50	57
Decline per cent 1929 from 1901 . .	42	0	4	33	59	60	57	52	35

The reason for this check in the fall in the death-rate at this period of life has not so far been accurately determined, but there are obviously several factors responsible and these are more fully considered in a subsequent chapter.

The most encouraging feature of the fall in the death-rate from tuberculosis since the commencement of the present century is the striking decline which is greater than at any other period in life in the rate under the age of five years. This feature is referred to in the report of an investigation by Dorothy Dow and Lloyd whose figures are quoted in this section. During the years 1898 to 1927 the mortality-rates from tuberculosis in England and Wales have declined by 75 per cent in children up to five years, 67 per cent in children between one and five years, 47 per cent in children between five and ten years, and 35 per cent in children between ten and fifteen years. The decline in the death-rate from various forms of tuberculosis under the age of five years for the

same period is as follows: abdominal tuberculosis, 89 per cent, pulmonary tuberculosis, 64 per cent, tuberculous meningitis, 62 per cent, and other forms of tuberculosis, 77 per cent.

TUBERCULOSIS AND THE HEALTH STANDARD. Tuberculosis is a disease which is the expression of an inadequate hygienic and sanitary standard. Wherever the conditions of life are associated with density of population, overcrowding, absence of sunlight, organic pollution of air and dust and insufficient food, the disease makes its appearance. The measure of the development of the disease depends upon the extent to which these conditions prevail and the susceptibility of the individual.

The hygienic and sanitary standard of communities throughout the world varies within extreme limits, and its various levels are indicated by outcrops of different diseases. When this standard reaches a low level it finds expression in the outbreak of such disease as smallpox, cholera, typhus, and typhoid fevers. These diseases were prevalent at certain periods during the nineteenth century, when the death-rate from tuberculosis during the 1851–1860 decade reached the high figure of 3,478 per million of population. They have ceased, however, to be a serious factor in the death-rate. The influence of an improved sanitary standard on the incidence of some of the commoner infectious diseases of childhood is not, however, so clearly demonstrated. During the years 1926–1935, associated with a progressive and pronounced fall in the death-rate from all forms of tuberculosis, there was a marked decrease in the death-rate from measles and whooping cough, while the death-rate from scarlet fever was practically stationary, and that from diphtheria showed an actual increase during 1934 and 1935.

During this period also the death-rates from bronchitis and pneumonia declined, the rates per million being respectively 773 and 828 for 1926, and 388 and 659 for 1935. The death-rate from pneumonia like that from tuberculosis is higher in urban than in rural districts, and like tuberculosis the incidence of the disease increases with the density of population. The decrease in the death-rate from pneumonia during the period referred to related chiefly to broncho-pneumonia and pneumonia (not defined); the death-rate from lobar pneumonia showed little

change though the figures were slightly lower. A high death-rate from tuberculosis is invariably associated with a high general death-rate, and a high infant mortality as is shown in the following table.

Standardized Death-rates from all Causes and from Tuberculosis compared with Infant Mortality and Infant Mortality from Tuberculosis, 1927–1936

Year	Death-rate per thousand	Per million		Infant Mortality	Infant Mortality from tuber-culosis
		Tuber-culosis (all forms)	Tuber-culosis (respiratory)		
1927	10·5	951	744	70	1·10
1928	9·9	908	709	65	1·08
1929	11·4	932	737	74	1·03
1930	9·5	872	683	60	0·90
1931	10·1	869	686	66	1·05
1932	9·7	815	636	65	1·00
1933	9·8	799	639	64	0·83
1934	9·3	740	586	59	0·69
1935	9·0	687	552	57	0·56
1936	9·2	657	525	59	0·59

A study of the above table reveals some well-recognized facts. A high mortality from tuberculosis is usually associated with a high general death-rate and a high infant mortality, so that the death-rate from tuberculosis and the infant-mortality may be accepted as a useful and reliable guide to the health standard of a community in the absence of an unusual prevalence of epidemic disease. The co-relation between infant mortality and infant mortality from tuberculosis is brought out in the table. Deaths from tuberculosis under one year have in the past been an important contributing factor in infant mortality, but, as is shown in the table, they are a diminishing figure. Dorothy Dow and Lloyd have pointed out that in 1898 of all deaths under one year 4·7 per cent were due to tuberculosis and that in 1927 the figure had fallen to 1·55 per cent, being an average yearly fall of 0·10 per cent. If the figures for the eight years to 1935 be considered

on the same basis it will be found that the percentage rates of deaths from tuberculosis was 0·98 with an average yearly fall of 0·19. The conclusion to be drawn from these figures and from the figures in the table is that the intensive campaigns which have been carried out now for some years against tuberculosis and for the promotion of infant welfare have accelerated the decline in the death-rate from tuberculosis under the age of one year and have consequently jointly contributed to the reduction in infant mortality.

If the position of tuberculosis as a disease menacing the public health is finally to be successfully assailed, efforts must be continued simultaneously and in co-ordination along three main lines, namely, the promotion of conditions of civilized life which will be antagonistic to pathogenic tubercle bacilli, the elimination of those circumstances which induce primary infection with subsequent clinical manifestations of the disease, and the provision of adequate facilities for treatment with a view to the restoration of health and of working capacity.

Chapter Two

TYPES OF TUBERCULOSIS

TUBERCULOSIS is the term applied to a disease characterized by special lesions which presents a variety of form and type both as regards character of infection and clinical manifestations, and it differs materially from the acute specific fevers with which it is to some extent classified for administrative purposes. Whereas in the diseases constituting the latter group the infection is of short duration, conforming except in degrees of severity to uniformity of type and conferring a more or less permanent immunity, tuberculosis, except in primary fatal infections, is more frequently a chronic disease of varying duration which may continue for years, or indeed throughout life.

The variation in type and form which is characteristic of tuberculosis presents a problem of considerable epidemiological importance and depends upon a number of factors, chief of which are the origin of the bacillus, degree of susceptibility, the location of gross lesions and the age of the individual when first infected.

ANATOMICAL DISTRIBUTION. The death-rates from tuberculosis are broadly classified under tuberculosis (all forms), and tuberculosis of the respiratory system. The detailed classification of deaths from tuberculosis of various structures are given by the Registrar General. (See table on page 21.)

Reference to this table indicates that the progressive fall in the death-rate from tuberculosis during the ten years 1926–1935 relate to all systems and structures involved, with the exception of the genito-urinary system. Here, although the death-rate is a low figure, it is fairly uniform and it will be observed that the mortality rate for 1935 was higher than that for 1926. The reason for this is difficult of explanation. It is possible that the incidence of the disease of this particular system is not favourably influenced by improved environmental conditions and specific protection to the same extent as tuberculosis involving other structures of the body, and that the ultimate results of existing methods of treatment of this condition are less favourable. It is well known clinically

that tuberculosis of the genito-urinary system always presents a serious problem as regards prognosis and treatment. In addition to the groups given in the above table, tuberculosis may involve other structures such as the skin, superficial lymph glands, and the eye, but these conditions are generally more amenable to special forms of treatment and they do not affect the mortality rate except by direct or metastatic extension to some important structure or organ.

Crude Death-rates from Tuberculosis of Various Organs per Million, 1926–1935

	1926	*1927*	*1928*	*1929*	*1930*	*1931*	*1932*	*1933*	*1934*	*1935*
Respiratory system	771	791	755	793	739	742	687	690	635	605
Central Nervous system	73	73	65	65	62	65	60	53	53	45
Intestines and Peritoneum	39	34	34	31	29	27	25	24	20	18
Vertebral column	14	13	12	12	12	12	12	11	11	11
Other bones and joints	8	8	8	7	7	6	7	6	6	5
Genito-urinary system	5	6	7	7	7	7	7	6	7	6
Disseminated tuberculosis	47	43	42	41	39	32	35	30	28	24

The death-rates from tuberculosis of these systems varies with age. Above the age of puberty tuberculosis of the lungs, of the vertebral column and of the genito-urinary system is more frequently met with, while below the age of puberty tuberculosis of the meninges, intestines, and peritoneum, and of bones and joints is more common.

TYPES OF INFECTION. The aetiology of the disease is discussed in a subsequent chapter; in this section consideration is given to the types of organism which are responsible for tuberculosis. The organism which is most frequently the causative factor in tuberculosis in man is the human type of the tubercle bacillus, and it is this organism which is usually found in the sputum of patients suffering from tuberculosis of the lungs, although exceptions occur. The bovine type of the bacillus is also responsible to some considerable extent for the development of tuberculosis in man more especially involving the abdominal

glands, bones, joints, and skin, especially under the age of fifteen. Cases of human infection with the avian type of bacillus also occurs, and the somewhat unusual occurrence of a mixed infection with both human and bovine type has been recorded. The relative frequency of the bovine type of infection in human tuberculosis has been exhaustively investigated by Stanley Griffith and the results obtained by him are given in the following table.

Variety of Tuberculosis	Number of Cases	Percentage of cases infected with Bovine type of Tubercle Bacillus		
		0–5 years	5–15 years	All ages
Cervical glands	133	84·0	51·5	48·9
Lupus	168	62·5	53·2	52·4
Scrofulodema	59	50·0	43·2	35·6
Bone & Joint	541	29·4	18·6	18·7
Genito-urinary	23	—	—	17·4
Meningitis	33	33·3	35·0	27·3
Pulmonary	795	—	—	2·6
Post-mortem cases	183	29·7	14·3	22·3

In the above table it will be observed that for all ages lupus gives the highest percentage of infection by the bovine type of bacillus, and that tuberculosis of the cervical glands is the next in order of frequency, although bovine infection of these glands gives the highest percentage under the age of five. The incidence of bovine infection in man would appear to be higher in Scotland than in England. Both Fraser and Mitchell had drawn attention in previous communications to the frequency of infection with the bovine type of bacillus in tuberculosis of bones and joints and of glands in Scotland. The subject of human infection of bovine origin in Scotland has been further elucidated by Blacklock in a comprehensive study on the incidence of tuberculous disease in children, and the following is a summary of his findings. In 1800, consecutive autopsies, 283 or 15·7 per cent showed naked-eye appearance of tuberculous infection. Of 165 strains

taken from children in whom tuberculosis had proved fatal, 120 or 72·7 per cent were of human type and 45 or 27·3 per cent were of bovine type. From 18 autopsies where death was due to other causes, the human type of bacillus was isolated in four cases and the bovine in 14 or 77·8 per cent. Of the total 183 strains examined, 59 or 32·2 per cent were of bovine type, which Blacklock points out is a much higher figure than that recorded for post-mortem findings in England and on the Continent. A further insight into the relative incidence of human tuberculosis of bovine origin in England and Scotland is given by Stanley Griffith in tables which he has compiled, giving the results obtained by himself and other investigators, excluding the cases of Mitchell and Fraser. In the following table, prepared from Griffith's tables, the percentages figures for all ages for England and Scotland are shown.

Percentage Infection with Bovine type of Tubercle Bacillus in England and Scotland

	Number of cases		Percentage with Bovine Infection (all ages)	
	England	Scotland	England	Scotland
Cervical Glands .	126	93	50·0	51·6
Lupus . . .	191	13	48·7	69·2
Bone and Joint . .	553	218	19·5	29·8
Genito-urinary . .	23	42	17·4	31·0
Meningeal . .	265	203	24·6	29·6
Autopsies . .	187	290	22·5	32·4
Miscellaneous . .	23	14	8·7	71·4

Some interesting facts emerge from the tables compiled by Griffith, which also give the incidence of bovine infection in the two age groups under five, and five to fifteen years. The highest percentage of bovine infection in Scotland was found in the strains obtained from lupus, the figures for the age groups under five years, and five to fifteen years being respectively 100 and 71·4 per cent for Scotland and 58·4 and 44·4 per cent for England, but it should be stated that there were only thirteen cases of this

disease for the former country compared with 191 for the latter. The proportion of bovine infection of cervical glands under the age of five years was much higher in England, the figure being 90·9 per cent compared with 65·0 per cent for Scotland. No cases of bovine infection of the genito-urinary system under the age of fifteen years is recorded for either country. Griffith states that with three or four exceptions all the cases of bovine origin found at autopsies were undoubtedly due to alimentary infection.

Further figures regarding the incidence of infection of the human subject with bovine tubercle bacilli are given in a report submitted by the Scottish Board of Health. The figures are based on 804 cases of tuberculosis, of which 166 were infections of the respiratory system and 278 cases of tuberculous meningitis. The ratio of bovine infection varied with age; under five years of age it was 38·2 per cent, in the five to fifteen age group it was 35·4 per cent, and over the age of fifteen it was 23·5 per cent.

The incidence of human tuberculosis of bovine origin is apparently higher in England and in Scotland than in some European and Asiatic countries. Blacklock gives the following percentage for the bovine type found in strains isolated from autopsy material taken from children. Berlin 4·3, Christiania 7·8, London 18·2, Edinburgh 60, and Glasgow 32·2. B. Lange states that for the whole of Germany up to 1936, the ratio of infection due to the bovine type of bacillus in 1,165 cases was 13·5 per cent.

One significant fact to be noted from a study of infection of the human subject with bovine tubercle bacilli is that pulmonary tuberculosis of bovine origin occurs more frequently than was generally supposed, and further it has been found that there exists some correlation between the incidence of this type of the disease and contact with cattle. Stanley Griffith has collated the results obtained from examination of the sputum by investigators in this country including Cumming, Munro, Wang, Lynn and Cutbill and himself, the ratio for the bovine type of bacillus varying from 0·52 to 8·5 per cent. In 1909 Griffith, when working for the Royal Commission on Tuberculosis, obtained pure cultures of bovine tubercle bacilli from the sputum of two men suffering from pulmonary tuberculosis. In 1933, Melrose Cumming and Winifred Foster reported a series of fourteen cases of pulmonary

tuberculosis of bovine origin; two of which were in persons who had been in contact with cattle. In a subsequent communication Cumming drew attention to the fact that in ten of these fourteen cases the pulmonary lesion had been preceded by a gross glandular lesion. A somewhat significant fact in accord with these results is that tuberculosis of the bronchial glands in young children shows a high percentage of infection with the bovine bacillus. Stanley Griffith and Munro found from the examination of bronchial glands obtained from autopsies of forty-six children under the age of five that thirty-four were infected with the human strain, ten with pure bovine strain, and two with a mixed human and bovine strain of organism. Stanley Griffith gives particulars of the geographical distribution of 163 cases of pulmonary tuberculosis with the bovine type of tubercle bacilli in the sputum in this country. The percentages of bovine type were: Scotland, North-East, 8·5 and 5; Middle and South, 4·6; England, North, 1·6; Middle, 1·5 and 0·9; South, 0·6 and 0·52; Wales, 1·0. Evidence of the existence of pulmonary tuberculosis of bovine origin also comes from Denmark, Germany, and other European countries. Jensen has recently reported twenty-six cases of tuberculosis, in thirteen of which the patients had been drinking raw milk and in eleven of which there was evidence of previous or existing glandular lesions. In Germany, B. Lange has reported that of forty cases of tuberculosis of the lungs diagnosed in dairy farm workers, eight, or 20 per cent, were due to bovine infection.

A mixed infection with both types of bacilli may also occur simultaneously in man. Eleven cases of this type in 6,000 or more cases examined bacteriologically have been recorded in this country as follows: Royal Commission on Tuberculosis, three; W. T. Monroe, three; A. S. Griffith, two; J. W. S. Blacklock, two; and W. M. Cumming *et. al.* one.

An interesting and possibly significant fact is elicited from a study of these cases of mixed infection. The mixed cultures recorded were obtained either from the lymphatic glands or lungs and in no case were the two types isolated from a lesion in the meninges, bones, joints, or kidneys.

Cases of mixed infection with both types of the tubercle bacillus have also been reported from Germany. Lange has

shown that in nine cases out of 1,028 examined bacteriologically up to 1932, both types of organism were isolated, and in Denmark, Jensen has noted seven such cases in a material of over 3,000.

Infection of the human subject with the avian type of organism also occurs, although there are no figures to correlate this type of infection with occupation. The occurrence of tuberculosis or suspicious lesions in workers amongst poultry should, however, always be investigated. Branch has described two strains of avian bacilli obtained from tuberculous lesions of the skin in man and refers to two interesting points in connection with his study of the subject. He has confirmed the association of avian strains of attenuated virulence with disease in man and has noted that acid-fast bacilli which can only be regarded as saprophytic in type also give rise to pathological changes in man.

The results obtained by these observers regarding the incidence of pulmonary tuberculosis of bovine origin in man in this country and on the continent open up an entirely new field for investigation regarding the epidemiology of the disease. There appears to be a connecting chain running through all these investigations linking up infection of lymphatic glands and lungs with tubercle bacilli of both human and bovine type which requires straightening out. One is tempted after a survey of the results obtained to assume that there exists foundation for the view held by Behring, Roemer, Calmette, and Much that mutation from the bovine to the human type of bacillus is a probable sequence of prolonged habitation in the human body. Middleton Martin draws attention to the strong evidence which exists in support of the view that the main source of infection in human tuberculosis is milk contaminated with the bovine tubercle bacillus. He considers that the alimentary tract is much more frequently the channel through which infection takes place than is the respiratory tract, and he favours the theory of mutation resulting from prolonged residence of the organism in the human body. In his contribution he emphasizes certain facts which can only be explained by this hypothesis.

If it could be proved conclusively that tuberculosis of the lungs due to the human type of bacillus were frequently a disease of young persons who had a primary bovine infection in childhood, it would rather tend to support the contention that mutation is

possible. If we accept the view that pulmonary tuberculosis in the adult is frequently an endogenous infection arising from a pre-existing focus due to a primary infection in early life, we should expect, having regard to the high percentage of cases of bovine infection of various structures in childhood, to find bovine tubercle bacilli in the sputum of adults much more frequently than actually occurs. The reason for this apparent discrepancy may rightly be attributed to varying methods of specific infection with the greater risk of exogenous pulmonary infection by the human type of bacillus. Stanley Griffith, who has isolated and typed many strains of the bovine bacillus from the human subject, states, however, that his bacteriological findings have attested a high stability of bovine bacilli and that no direct evidence exists in favour of mutation taking place in the human body. Here for the present we must leave this problem, which, however, presents aspects which call for further elucidation.

AGE GROUP TYPES. The death-rate from tuberculosis falls heaviest on certain age groups, namely, under five, at the age of fifteen to thirty, during the years of middle life, and over the age of sixty. The type of the disease also varies in different age groups; whereas in young children the highest death-rates are due to generalized or meningeal tuberculosis, in adults the death-rate from pulmonary tuberculosis largely predominates. In a susceptible population the death-rates under five and in the young adult age group show the highest peaks, but in a relatively protected population these peaks tend to recede and there occurs an upward trend at middle life and over the age of sixty. In this and in other countries, however, the recession of the young adult peak has been minimal in the case of females compared with that of males.

A study of the relationship between the mortality rate from tuberculosis at different ages and of the form or type which the disease assumes in different age groups, throws light on the aetiology of the disease. If a graph of the death-rate from tuberculosis for the year 1927 be studied, the distinctive characteristics of the curve will be noted. In males under five years the mortality peaks from both forms of the disease are high and pointed, and are only exceeded by the rounded peaks representing deaths from respiratory disease in the years of middle life. In females

the mortality peaks from both causes under five years are considerably lower than the corresponding peaks for males, and they are approximately equal to the young adult respiratory peaks from which the curve descends with a slight rise in middle life and at the age of sixty-five to seventy.

An analysis of the types of tuberculosis responsible for deaths at various ages indicates distinctive features of the disease in relation to recognized age groups, and to sex in these age groups; this is shown clearly in the table on page 29.

TYPE IN YOUNG CHILDREN. It will be observed from the figures in the opposite table that in the two age groups under one and one to five, tuberculosis of the central nervous system is by far the most frequent cause of death and that the number of deaths in males is higher than that in females. Next in order but at a much lower level are the figures for deaths from tuberculosis of the respiratory system and from disseminated tuberculosis. The wide difference between the number of deaths from tuberculosis of the central nervous system and from the two latter types below the age of five is striking. Tuberculous meningitis is well known to be the frequent terminal manifestation of a primary infection, but all cases of meningitis in young children are not tuberculous in origin and the difficulties of diagnosis in the absence of any other evidence of infection are recognized. In a series of seventy-eight cases of tuberculosis in infants investigated by Dorothy Price, sixty died from the following conditions:—pulmonary tuberculosis 22, miliary pulmonary 18, tuberculous meningitis 17, abdominal 2, congenital 1.

YOUNG ADULT TYPE. The young adult type of the disease is responsible for the highest number of deaths of any age group, and the deaths amongst females predominate. Tuberculosis of the respiratory system is the principal cause of death between the ages of fifteen and thirty. Next in order come deaths from tuberculosis of the central nervous system and from disseminated tuberculosis. It will also be observed that the number of deaths from tuberculosis of the genito-urinary system increases with sexual development and that deaths from tuberculosis of the vertebral column and other bones and joints fall heaviest on the ages between fifteen and thirty, a period of life when strain and trauma are most likely to be met with.

Deaths from Tuberculosis, various Forms, at Different Age Periods, 1935

Ages at Deaths	Respiratory System		Central Nervous System		Intestines and Peritoneum		Vertebral Column		Other Bones and Joints		Genito-urinary System		Disseminated Tuberculosis	
	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.
0	25	23	101	81	32	13	1	—	1	1	1	—	28	25
1– 5	58	75	373	294	65	33	7	5	6	1	1	—	69	74
15–20	624	1,110	88	81	35	57	16	8	9	6	9	5	77	44
20–25	1,459	1,919	58	49	31	47	30	22	14	4	13	18	59	43
25–30	1,541	1,676	37	35	33	35	33	12	12	2	18	11	45	40
45–50	1,447	595	11	7	18	16	18	9	3	3	10	7	19	17
60–65	904	355	3	3	7	10	12	10	10	10	9	4	7	10

Brownlee in his investigation already referred to, calls attention to the correlation between the incidence of tuberculosis of the respiratory system in young adults and certain environmental conditions and circumstances. He states that the disease is more common in districts exposed to south-west winds and in those above glacial clay and among persons whose employment exposes them to wind and wet. He also states that the disease is less common in districts where large numbers of deaths from tuberculosis occur in children and in those counties from which large quantities of milk are sent to London. Is the apparent correlation between a restricted milk supply and a lower incidence of pulmonary tuberculosis in young adults purely accidental or does it provide a pointer to an aetiological connexion between this form of tuberculosis and the bovine type of bacillus?

The reason why the death-rate from pulmonary tuberculosis amongst females in the young adult group shows little tendency to decline is a problem to which much attention has been given for some years. The inverse relationship between the prevalence of the disease at this age and deaths from tuberculosis in childhood mentioned by Brownlee is borne out as regards sex incidence by the death returns for 1935. While in the young adult female age group the deaths from pulmonary tuberculosis predominate, it is noted that between the ages of one and five years the deaths amongst males from tuberculosis of all systems mentioned, except those from pulmonary tuberculosis and disseminated tuberculosis, are higher, and that under the age of one year the deaths from all forms of the disease predominate amongst males.

This inverse relationship between the mortality from tuberculosis under the age of five and the mortality in the young adult age group is clearly brought out in a statistical table which appears in the Ministry of Health's Report on Tuberculosis in Wales from which the figures given opposite are taken.

It will be observed from the figures given in this table that whereas the mortality in the under five age group is lower in Wales than in England for both sexes, the mortality in Wales in the fifteen to twenty-five group is very much higher. In considering the explanation of this it is necessary to take into account the protective influence of a primary non-clinical infection under the age of five, the source of infection in the older group, the adverse

satisfied that many young females voluntarily restrict the intake of fat-forming foods, a practice which results in deprivation of vitamins A and D. The intimate structural connexion between vitamins and hormones which has recently been the subject of a monograph by Brederick of Leipzig, also points the way to the possible existence of disharmony in complicated bio-chemical interchange as a probable factor in lessening physical resistance to progressive infection during the earlier years of sexual activity.

The young adult type of pulmonary tuberculosis presents a serious problem from the point of view of contact infection, as the contacts are frequently young, while the association between a young mother and her infant is intimate and provides every facility for massive dosage by droplet infection.

MIDDLE AGE TYPE. The type of tuberculosis met with in middle life is of a chronic type with well-marked fibrotic changes, and the fatal effects of the disease at this age fall heavier upon males than females owing chiefly to industrial conditions. When the mortality peak in the years of young adult life is relatively low there is a tendency for the death-rate to rise sharply during middle and later life and this upward trend in males is much more marked in some other countries than in Great Britain. One of Brownlee's conclusions from his investigations was that the disease in young adults was less common in districts where there was much middle age tuberculosis. Fatal tuberculosis in middle life may occur as an acute exogenous infection, but it is much more frequently the end result of a prolonged struggle between the resisting forces of the body and an infection which has been contracted in early life. The infection has been kept in check or the disease has progressed slowly through phases of quiescence and recrudescence of varying duration until the defensive powers have given way to the stress of time and the strain of industrial life.

Tuberculosis in the middle years of life is frequently associated with attacks of bronchial catarrh and asthma. The autopsy in asthmatics of a certain type has revealed the presence of gross central lesions in the lungs. Fraenkel has investigated 369 cases of bronchial asthma and in 62, or 16·8 per cent, found evidence of past or present tuberculosis based on X-ray findings and

sputum examinations; sixteen of these cases had evidence of active tuberculosis. The prolonged course which this type of the disease may assume with the expulsion, in some cases unsuspected, of tubercle bacilli for a protracted period, makes it one of the most fertile sources of infection in the home, more especially as the chronicity of the disease tends to laryngeal involvement.

SENILE TYPE. The senile type of pulmonary tuberculosis is usually the terminal phase of an infection which has lasted throughout life. It develops clinically after the age of sixty, or later, when with waning physical powers, resistance becomes enfeebled. It may be detected in quite old people and the writer has before him the records of two women aged eighty-one and eighty-three respectively, who presented clinical pictures of the disease. During the years 1933–1936 in the County of Hertford the highest percentage of primary notifications of persons of the age of sixty-five plus suffering from pulmonary tuberculosis was 3·6 for males and 4·5 for females, and of persons of that age group suffering from non-pulmonary tuberculosis 1·7 for males and 3·1 for females. The stethoscopic diagnosis of senile tuberculosis of the lungs is usually difficult, owing to feeble breath sounds and the degree of emphysema which is present. Lander states that the autopsy shows cavities surrounded by thick fibrous walls, and X-ray examination reveals intense bilateral fibrosis. Senile tuberculosis is probably less dangerous as a source of direct infection than other types of the disease, as sputum is frequently scanty owing to less active caseation, and there is less contact with young susceptible subjects, but the risk of infection must not be overlooked.

Senile tuberculosis of a somewhat benign character as stated by Enid Williams is observed in miners, especially those who have worked in anthracite. It has been suggested that the benign character of this senile form of the disease is due to the restrictive effect of coal dust upon the toxic products of the tubercle bacilli. In this country tuberculosis in later life is less frequently a cause of death than in some other countries. In the United States the mortality curve for males rises steeply after the age of forty-five and reaches a peak which is well maintained; the influence of industrial conditions with impaired resistance to tuberculosis is no doubt responsible for this upward trend.

CLINICAL TYPES. Tuberculosis is a disease which presents considerable variation in type according to the character of the organism, the structure or organ principally involved, the stage of development of the disease, the degree of activity or chronicity, and the extent to which the type may prove to be a source of infection. Although the brunt of infection must frequently fall on some special organ or structure, it is necessary to remember that tuberculosis is a general infection which may lead to outcrops of disease in almost any organ or structure of the human body.

It is customary to speak of a tuberculosis lesion as being 'closed' or 'open' according to the absence or presence of external communication which would permit of the shedding or passing of tubercle bacilli. A lesion is only to be regarded as closed if it were conclusively proved that no tubercle bacilli or virus were being expelled at any time in sputum, discharge, gastric washings, faeces, or through any other medium or channel. This obviously would be difficult to determine as, apart from the strict investigation required, the same case may present negative as well as positive phases. It is a wise precaution to regard every closed case of manifest tuberculosis as potentially an open case and as a possible source of infection.

Tuberculosis of the lungs is the type of the disease which most frequently and most rapidly becomes open; it is the principal *fons et origo* of the human type of bacillus and is the chief cause of massive infection. It is only in the early stages of the disease before caseation and breakdown of tissue take place that a pulmonary infection may exist without the expulsion of tubercle bacilli. Tuberculosis of other organs and structures, owing to their locality and function, does not provide the same facilities for the rapid expulsion of large quantities of tubercle bacilli. Tuberculosis of glands, bones, joints, or serous membranes may exist without external communication for long periods, and although usually considered to be innocuous as regards the production of contact infection, the fact that the lung is invariably the seat of the primary infection must not be forgotten. Sinuses however, do occur in cases of diseases of bones, joints, and glands, and where mixed infection supervenes, considerable discharge with the shedding of tubercle bacilli may exist. In certain cases

also, tubercle bacilli may be expelled in the faeces or in the stomach contents during attacks of sickness.

The various types of tuberculosis of the lung differ in their potentiality to convey infection. The active rapidly caseating type with much sputum teeming with bacilli is the chief source of danger, as it may give rise to massive infection. The chronic fibrotic type with less sputum containing fewer bacilli is equally a source of infection owing to the prolonged period during which tubercle bacilli may be expelled. Cough *per se* is also a factor in infection, as the stronger and more explosive it is in character the greater is the possible range of droplet infection.

Pulmonary tuberculosis of the pneumonic and broncho-pneumonic types is usually of sudden onset and the patient is at once seriously ill; the disease may be rapidly progressive and result in a fatal termination in a comparatively short space of time. Infection from cases of this acute type is likely to be more easily controlled, although the pneumonic type may pass into the less acute caseous type.

The advanced caseating type of pulmonary tuberculosis with cavitation and abundant sputum is a fertile source of infection. During the closing stages of the disease with diminished powers of cough and of clean expulsion of sputum, the face, hands, handkerchief, and bedclothes are liable to become contaminated, and although the risk of droplet infection from cough diminishes with failing powers, the risk of dust infection from dried sputum is increased.

Miliary tuberculosis of the lungs is usually rapidly fatal and is not associated with the expulsion of much sputum containing tubercle bacilli. The acute type of this disease presents a clinical picture which cannot be mistaken. The sudden onset, the high temperature, the rapid pulse and respirations—the latter may reach seventy per minute—the marked cyanosis, and the high red corpuscle count are characteristic; in such cases the autopsy, as the writer has found, reveals miliary tubercle of both lungs from apex to base.

Attention has recently been directed to a chronic type of miliary tuberculosis as a distinct and separate form of the disease. Hoyle and Vaizey have investigated the presence of this form of the disease. The same authors have explored the literature on the

subject and have studied 110 cases which in their opinion conformed to a chronic type of miliary tuberculosis of the lungs. Pagel, however, demurs at the designation chronic miliary tuberculosis, and prefers the term chronic disseminated tuberculosis, while Burton Wood describes the condition as miliary epituberculosis. The term miliary tuberculosis connotes the impregnation of the pulmonary tissue from apex to base with minute tubercles, a condition which postulates systemic infection in a non-protected subject and which is incompatible with any conception of chronicity. Pagel states that in patients in whom a condition simulating chronic miliary tuberculosis is found, the post-mortem evidence of tuberculosis is not infrequently absent, and he regards the miliary spread as silicotic rather than tuberculous in origin. There exists sufficient evidence to prove that the diagnosis of miliary tuberculosis of the lungs by X-ray examination is uncertain. A case of this kind was recently brought to the writer's notice by his deputy, A. P. Ford. The patient was a child acutely ill in whom the diagnosis of miliary tuberculosis was based on X-ray findings, but the pulmonary picture cleared within three months time.

TUBERCULOUS BACILLAEMIA. Tuberculous infection is frequently conveyed through the blood stream and the presence of tubercle bacilli in the blood at some period in the course of the disease must be a fairly frequent occurrence. Haemic infection is responsible for generalized tuberculosis, miliary tuberculosis and various forms of non-respiratory disease. The frequency with which tuberculous bacillaemia occurs has been exhaustively investigated by Wilson, who concluded that the researches carried out on this subject give the following results as regards percentages of tubercle bacilli in the blood: pulmonary tuberculosis 4·9, miliary or meningeal tuberculosis 36·4, and non-pulmonary tuberculosis 2·7. Although bacillaemia is responsible for metastatic infection, it is also, as pointed out by Pottenger, the means by which self-protection against further infection may be induced in consequence of the disintegration of the bacilli in the blood stream and the liberation of endotoxins.

Bacillaemia is more common in childhood than in adult life and is more frequently associated with primary infections and with the absence of specific protection, but it is also associated

with secondary infections. Its significance refers to its causal relationship to metastatic infection and to its possible connexion with specific protection. It gives rise *per se* to no recognized clinical manifestations, although Pottenger suggests that it may be responsible for the sudden exacerbations of temperature which are sometimes observed during the course of the disease and for variations in tuberculin skin reactions.

ASSOCIATED LESIONS. Tuberculosis is a general infection and the clinical manifestations of metastatic lesions may be observed in a considerable percentage of cases. It is necessary to distinguish between overt clinical evidence of disease and the evidence of infection found on more careful investigation. The respiratory system is the primary seat of infection in the great majority of cases, but the clinical evidence of gross extra-pulmonary lesions may precede or follow clinical pulmonary infection. In his own experience the writer has met illustrations of active pulmonary disease following tuberculosis of skin, bones, joints, spine, lupus of the nose, and other structures; in many cases of this type the primary infection is respiratory, but exacerbation of the primary infection does not occur until after the development of manifest disease elsewhere; in other cases as in direct bovine infection of the skin or cervical glands, the pulmonary infection is the metastatic outcrop of a systemic or lymphatic infection.

Petter gives a complete analysis of the lesions found in 976 tuberculous patients discharged from the Glen Lake Sanatorium, Minnesota. He emphasizes the tendency which still prevails among medical men to regard the various manifestations of tuberculosis as separate clinical entities rather than the local expression of a general infection, and he pointedly draws attention to Louis's law that 'tuberculosis of any part is attended by tuberculosis in the lungs'. The figures submitted by Petter emphasize the importance of viewing tuberculosis in its true perspective as a general infection and of considering the question of treatment, especially in cases in which non-pulmonary manifestations of the disease predominate, from this standpoint. A summary of his findings is shown in the table on page 38.

Two points of importance emerge from a study of these and further figures submitted by Petter in his communication. He

Percentage Incidence of Non-pulmonary Lesions in cases of Pulmonary Tuberculosis

Stage of Pulmonary Tuberculosis	Tubercu-lous Laryngitis	Intestinal Tubercu-losis	Bones and Joints	Genito-Urinary	Rectum	Glands	Ear	Peritoneal
Far advanced 527	20	14	5	3	4·7	1·7	3·2	1·3
Moderately advanced 242	4	6	7	2·5	3·7	4·1	1·2	1·2
Minimal . 78	0	1·2	18	1·3	—	3·8	1·3	3·8

quotes Harris, who states that in the majority of bone cases, a pulmonary lesion with concomitant mediastinal adenitis will be found, and that renal tuberculosis is particularly liable to accompany bone lesions, and he concludes by saying, 'Every patient showing orthopaedic or genito-urinary tuberculosis should have the benefit of chest X-rays, because 60 per cent of our bone and joint cases and 48 per cent of our renal cases show pulmonary pathology. Similarly every patient with bone and joint tuberculosis should have careful genito-urinary examination, for 10 per cent of our group were found to have renal involvement.'

SPECIAL TYPES. Tuberculosis is a disease which is influenced as regards type by various factors. Age, environmental conditions and mental enfeeblement may alter the clinical picture presented by the pulmonary form of the disease and give rise to specially recognized types.

In young adolescent females a severe type of infection with characteristic features not infrequently occurs. The constitutional disturbance is marked from the onset and finds expression in anaemia, high temperature, rapid pulse, tremor, myoidema, sickness and wasting. The physical signs are usually restricted at first to the sub-clavicular region and consist of characteristic moist sounds, but the actual lesion is much larger than the physical signs suggest. The disease spreads rapidly, followed by caseation and cavitation, and before the days of treatment by artificial pneumothorax, was invariably fatal. This type of the disease was commonly met with in Scotland in the early years of the present century, but in England and on the Continent it is at the present time less active and progressive in character and is now earlier recognized. It has been described by German and French authorities and the very appropriate term of 'infra-clavicular infiltration' has been given to it by Assmann and Redeker. Armand-Delille states that if the patient is not efficiently treated at the early stage cavitation develops, when pneumothorax must be induced without delay. Burrell had stated that in the acute young adult type the X-ray picture shows a large opacity at an early stage, which is partly due to an inflammatory zone round a tuberculous focus which often goes on to cavitation at an early stage, and that in the acute young adult type a history of recent exposure to massive infection is not uncommon.

In this form of the disease tubercle bacilli are shed at an early stage, although at first sputum may be scanty, and it therefore presents a serious source of infection in the home.

The type of pulmonary tuberculosis varies according to environmental and industrial conditions and an urban and rural type has come to be recognized. It has long been known that owing to specific protection, those who have been born and brought up in large urban districts are more resistant to tuberculous lesions than those who live in rural areas. When tuberculosis develops in those who have migrated from isolated rural districts to crowded urban districts it generally assumes a more active and progressive character. The difference between the clinical features of tuberculosis in town dwellers and that in country dwellers has been made the subject of a special study by Tomanek who examined 1,860 cases of tuberculosis from country districts and compared them with 1,824 cases from towns. His conclusions are as follows. In country dwellers infiltrations are approximately twice as commonly met with, bilateral disease is three times more common, tuberculosis of the skin, mucous membrane, larynx, and lymphatic glands is more frequent, and generally the disease is more serious and more rapidly progressive in character. In town dwellers the middle age and senile types are more frequently met with than in country dwellers. These findings are in accord with accepted views regarding the influence exercised by specific protection on the clinical manifestations and course of the disease. They emphasize the necessity for due allowance being made in regard to variation in type when surveys of the clinical features of the disease in any particular district are made, as for example in comparing the young adult type in a remote rural district with the same type in a populous urban district.

The clinical features portrayed by tuberculosis when it develops in mental defectives and persons suffering from progressive dementia differ widely from those observed in normal persons. In an investigation made by Elkins and the writer on the incidence of tuberculosis among patients in a mental hospital, it was found that the disease conformed in few features to that commonly seen in mentally normal individuals. Although post-mortem findings proved the existence of pulmonary lesions, the classical symptoms

of the disease, namely, cough, expectoration and fever, were invariably absent, the clinical picture being one of progressive wasting, associated with abdominal symptoms, chiefly diarrhoea.

CLASSIFICATION. For practical purposes it is necessary to classify patients suffering from tuberculosis of the lungs into various groups according to the area of the lesion or lesions and the severity of the infection. Various methods of classification have been adopted of which the Turban Gerhardt method is best known; this is as follows:

Stage 1. Early disease of slight severity affecting the apex of one lobe or if both apices are involved, not extending beyond the clavicle or spine of the scapula.

Stage 2. Disease of slight severity affecting not more than two lobes, or if more severe, affecting not more than one lobe.

Stage 3. All cases of greater extent or severity than Stage 2.

The classification recommended by the Ministry of Health for administrative purposes is as follows:

Patients should be classified according to the organs or parts affected as follows:—

(1) Pulmonary tuberculosis (including tuberculosis of the pleura or intrathoracic glands).

(2) Non-pulmonary tuberculosis.

Patients suffering from both pulmonary and non-pulmonary tuberculosis should be classified as pulmonary cases.

Patients suffering from pulmonary tuberculosis should be divided into

Class T.B. minus, viz., cases in which tubercle bacilli have never been demonstrated in the sputum, pleural fluid, faeces, etc., and

Class T.B. plus, viz., cases in which tubercle bacilli have at any time been found. It should be noted that a patient originally in Class T.B. minus must be transferred to Class T.B. plus at any stage in the course of treatment if and when tubercle bacilli are found, while on the other hand a patient who is once placed in Class T.B. plus can never be included in Class T.B. minus. Class T.B. plus should be further subdivided into three groups as follows:—

Group 1. Cases with slight constitutional disturbance, if any; e.g. there should not be marked acceleration of pulse nor elevation of temperature except of very transient duration; gastro-intestinal disturbance or emaciation, if present, should not be excessive.

The obvious physical signs should be of very limited extent, as follows:—Either present in one lobe only and, in the case of an apical lesion of one upper lobe, not extending below the second rib in front or not exceeding an equivalent area in any one lobe; or where these physical signs are present in more than one lobe, they should be limited to the apices of the upper lobes, and should not extend below the clavicle and the spine of the scapula.

No complication (tuberculous or other) of prognostic gravity should be present. A small area of dry pleurisy should not exclude a case from this group.

Group 3. Cases with profound systemic disturbance or constitutional deterioration, with marked impairment of function, either local or general, and with little or no prospect of recovery.

All cases with grave complications (e.g. diabetes, tuberculosis of intestines, etc.), whether those complications are tuberculous or not, should be classified in this group.

Group 2. All cases which cannot be placed in Groups 1 and 3.

Patients suffering from non-pulmonary tuberculosis should be classified according to the site of the lesion as follows:—

(1) Tuberculosis of bones and joints.
(2) Abdominal tuberculosis (i.e. tuberculosis of peritoneum, intestines, or mesenteric glands).
(3) Tuberculosis of other organs.
(4) Tuberculosis of peripheral glands.

Patients suffering from multiple lesions should be classified in one sub-group only, viz., in that applicable to the case which stands highest in the immediately preceding list.

A symbolic classification as first suggested by Sir Robert Philip is found to be a useful and practical method of recording the findings on examination and in providing a record which will enable one to envisage readily the extent of the disease and the severity of infection. In such a system R and L represent lung involved, S represents systemic infection, Roman figures indicate the extent of the disease in the lungs, and numerals the severity of infection, thus:

R I	R II	R II
— S_1	— S_2	— S_3
L	L	L II

would represent three stages of the Turban Gerhardt classification.

Types of Tuberculosis

A system of classification based on radiological findings from a simple flat photograph has been recommended by Watt, who advocates that the classification adopted should not be too detailed, but should consist of broad groupings which are not likely to be upset by future developments in radiography. The pathological conditions which form the basis of his classification are as follows:

A. Primary stage.
B. Pleuritic forms.
C. Miliary pulmonary tuberculosis.
  (1) Proliferative.
  (2) Exudative.
D. Phthisis.
  (1) Proliferative.
  (2) Exudative—pure or mixed, but without cavitation.
  (3) Exudative—cavernous.
  (4) Fibro-cavernous.
  (5) Fibroid—pure or calcified.

Working on these pathological groups, Watt recommends the following clinical classification for administrative and statistical purposes. Minimal: discrete, proliferative, exudative, or fine fibrotic lesions, without cavitation and limited to a total area not exceeding a third of one lung field. Moderately advanced: lesions of the same kind, and extent, but with cavitation; or lesions of the same extent but confluent; or lesions of the same kind, limited to a total area greater than one third, but not exceeding two-thirds of one lung field. Far advanced: lesions of greater extent or severity. In his paper Watt discusses at length the interpretation of the pathological conditions which form the basis of his classification, namely, proliferation, exudation, caseation, cavitation, and fibrosis. He states that caseation cannot be distinguished radiologically from other conditions of airless lung. He defines an exudative lesion as one in which the essential feature is the plugging of the air vesicles with exudate, a condition comparable to that found in pneumonia; and a proliferative lesion as one which consists of characteristic tubercle or tubercles. This method of classification is one which, consistently applied, should prove of definite value to clinicians who have to interpret the

various stages and phases of the disease in relation to prognosis and treatment. It assumes, however, that the X-ray picture provides an accurate indication of the character of the lesions present, and regarding this, there may be some difference of opinion among experts. The term exudative requires to be more clearly defined in relation to the pathological changes in the lungs induced by tuberculous infection. It is difficult to visualize as tuberculous pathological entities a pure exudative infection or an exudative miliary tuberculosis of the lungs. On these points some clarification is desirable, but the classification is one which will prove of practical value to the radiological study of the various pathological phases of pulmonary tuberculosis.

Chapter Three

AETIOLOGY AND INFECTION

THERE still exists considerable diversity of opinion as to the relative importance to be attached to certain factors in the aetiology of tuberculosis. It is generally accepted that the bacillus of the human type is the main cause of the disease in adults and that the bacillus of bovine type is responsible for a high percentage of extra-pulmonary lesions in children. There is less agreement, however, regarding the various factors which contribute to the development of clinical manifestations of tuberculous infection in man, possibly because the conditions of life which appear to facilitate the development of the disease are many and varied, and for the reason that their effect may be the result of combined rather than isolated action.

In discussing the aetiology of the disease it is necessary to start from certain accepted data; these are (*a*) that a varying ratio of individuals possess inherited immunity to infection, (*b*) that a considerable ratio of individuals when infected are protected against clinical manifestations of the disease, (*c*) that in the remainder definite and recognizable lesions develop which show a wide variation as regards extent, severity, progression and the disability to which they give rise and (*d*) that the balance between clinical infection and resistance is frequently weighted against the individual by adverse influences arising from habits, environmental conditions, and other factors.

PARENTAL TRANSMISSION. The role of heredity in the aetiology of tuberculosis is still a debatable point. From a knowledge of individual cases which remain resistant, although exposed to massive or prolonged contact infection, one has to accept the view that an inherited immunity to tuberculous infection occurs in some individuals. This immunity may be complete or partial, and when the latter may be reinforced by specific protection. There is no evidence that complete specific protection can be transmitted by infected progenitors, although partial protection of this character is postulated as the explanation

of the chronicity of the disease which is characteristic of certain races, notably the Jews and the native races of China.

The occurrence of an inherited predisposition or lack of resistance to tuberculous infection has been accepted as a factor in the aetiology of the disease. Evidence in favour of this view is to be found in the acute manifestations of the disease which not infrequently occur in several members of the same family. Those who oppose the view as to the possible existence of inherited predisposition naturally point to massive infection and to the influence of some common adverse factor or factors as the explanation of such incidence. While the existence of both these factors is admitted, they do not completely explain the incidence of acute and fatal disease, especially in well-to-do families. The rapidity with which members of these tuberculous families succumb to the disease suggests the absence of any resistance to infection apart altogether from the question of dosage, which cannot have been equally massive in all cases.

Karl Pearson, who carried out a statistical investigation on the subject, came to the conclusion that inheritance was an important factor in the aetiology of pulmonary tuberculosis. On the other hand, Ford found no support of this view in a study of the family history of 1,000 cases of pulmonary tuberculosis with positive sputum, as in only 20 per cent was a family history of tuberculosis elicitated. Bradbury, also, in his investigations into the causal factors in tuberculosis in Blaydon and Jarrow, found no evidence that family history had any significance. The author found in a series of 227 children of school age who had been treated since 1930 at the Children's Sanatorium, Harpenden, on account of clinical manifestations of tuberculosis, or because of reactive evidence of infection, a family history of the tubercolosis in 57·26 per cent, and a history of contact in 40·09 per cent. Boland expresses the view with reference to the role of heredity in the development and incidence of tuberculosis that in the experience of all of us there are anomalies of familial infection which are difficult to explain if the conception of inherited susceptibility is excluded. He regards the problem of the role played by heredity to be not merely of academic interest, but to have important implications in relation to our social system.

Crew and Fraser Roberts in reviewing the evidence relating to

the role of heredity in tuberculosis, state that as would be expected, it is less clear-cut and more difficult to distinguish, but that it must play an important part in determining whether or not tubercle bacilli which have established themselves in the human body will or will not multiply and give rise to clinical tuberculosis. The authors point out that the modern genetical view of resistance and susceptibility is something much more than a return to the older conceptions of diathesis, and that if the agencies which determine resistance and susceptibility are partly genetic and partly environmental the improvement in environmental conditions will tend to emphasize the genetic aspect of the difference between individuals.

Davidson, in discussing the resistance-ratio of the individual, states: 'the occasional development of a rapid and intractable form of the disease in several members of a family successively, would seem to support the belief that some inborn peculiarity of metabolism is mainly responsible.' The subject is further discussed under the heading 'group infections'.

Congenital tuberculosis occasionally occurs when the mother is the subject of active disease, and over sixty authentic cases have been reported. Infection takes place through the umbilical vein and gives rise to a primary focus in the liver, or from infected amniotic fluid *via* the respiratory or gastro-intestinal tract in which the primary lesion develops. A further possible source of intra-uterine infection has been postulated by Calmette and others, who consider that filterable elements of the tubercle bacilli may pass through the placenta from mother to foetus, and after a period of latency give rise to definite lesions in the child, but this view has not so far been substantiated. A case of congenital tuberculosis has recently been reported by Dorothy Price. The mother was first treated for tuberculosis of the lungs in 1934. The infant, a male, died when forty-nine days old, after several days' illness with a temperature reaching a maximum of 102° F. but with no physical signs. The autopsy showed disseminated foci in both lungs; the liver and spleen being studded with miliary tubercles and there was a large mass of glands in the neighbourhood of the portal vessels, one of which was regarded as the primary focus of infection.

DEFICIENCY IN FOOD REQUIREMENTS. There exists a considerable amount of evidence in support of the view that resistance to tuberculosis is impaired when the food taken is inadequate or is lacking in certain important constituents. It has long been known that the tuberculous patient has frequently a dislike for fat, and a diet which is deficient in fats and proteins, vitamins A and D and mineral salts, especially calcium, certainly appears to be associated with an impairment of the defensive forces against infection by tubercle bacilli. The influence of insufficient food as a factor contributing to the incidence of tuberculosis was demonstrated during the War by the rapid increase in the death-rate from the disease in those districts, especially in Austria and Germany, where food shortage was severe. Sir Arthur MacNalty has drawn attention to the position in Lille during the three years of German occupation. The death-rate from tuberculosis which was 3·30 per 1,000 before the War, rose to 5·73 per 1,000. For young persons under the age of nineteen the death-rate increased almost 100 per cent. The energy value of the diet which was poor in proteins, fats, and vitamins, was rarely above 1,600 calories, and it was especially deficient in vitamin A, as milk was unobtainable and butter could only be secured at a very high price.

A study of 'Group Infection' as shown in some families, in schools and in other institutions, also supports the view that a deficiency in diet is an important contributing factor and is indeed, apart from contact infection, the only one which can be accepted as common to all groups.

In the Report on Tuberculosis in Wales which has been recently published, importance is attached to the necessity of maintaining the nutrition of young children at a high level in order to increase their protective resistance against tuberculosis during the subsequent period of stress associated with early adult life. Attention is drawn to the fact that especially in rural areas the amount of protective foods including milk and fresh vegetables is inadequate, and that the staple diet consists of tea, bread and butter, jam and prepared foods. This inadequate dietary associated with insanitary and overcrowded domiciliary conditions is responsible for the considerable amount of poor nutrition,

more especially in the rural districts in Wales to which the Committee makes special reference.

In the Tyneside inquiry carried out by Bradbury, the question of under-nourishment in relation to tuberculosis was fully investigated. The following figures taken from his report give a brief summary of the consumption per head of various foodstuffs:

Average Consumption of Foodstuffs per Head per Week:

	Meat (lbs.)	Butter (ozs.)	Bread (lbs.)	Milk (pints)
Jarrow				
Tuberculous families . .	0·73	2·21	5·91	0·48
Non-tuberculous families .	0·84	2·73	5·52	0·67
Blaydon				
Tuberculous families . .	0·81	2·81	6·42	0·67
Non-tuberculous families .	0·95	4·13	5·80	1·17

In the above table it will be observed that in Jarrow with the higher death-rate the consumption per head of meat, butter, and milk was lower in tuberculous than in non-tuberculous families. In Blaydon with a much lower death-rate than Jarrow, where the same difference occurs, the consumption of these articles of food, especially butter and milk, was much higher. The higher amount of milk consumed by non-tuberculous families and the fact that more bread was consumed in tuberculous than in non-tuberculous families will be noted.

Bradbury discusses at length the implications arising from the data obtained as to the association of under-nourishment with tuberculosis. These point to under-nourishment as being responsible for a condition of impaired resistance to tuberculosis and also to sickness and disease other than tuberculosis. They also show that among tuberculous families there is a greater proportion of child patients in under-nourished than in well-nourished families. This means that the effect of under-nourishment in impairing resistance to infection falls heavier upon the growing child than upon the adult. The causative relationship between under-nourishment and disease is shown in the following table:

Percentage of Under-nourished Families:

	Families with no Sickness	Families with Sickness other than Tuberculosis	Tuberculosis Families
Jarrow	31·1	38·0	48·9
Blaydon	6·8	10·6	18·9
Jarrow and Blaydon . .	21·1	29·6	43·7

In estimating the possible role of under-nourishment as a predisposing cause of tuberculosis, consideration has to be given to the existence of other associated conditions which might adversely affect resistance to disease or facilitate infection, and of these the most important is overcrowding. Bradbury recognized the possible influence of this factor and took steps to eliminate it by studying the effect of under-nourishment on families who were not living under overcrowded conditions. The results of his observations indicated that the causative relationship between under-nourishment and tuberculosis still held good, and he concludes by stating that 'the evidence warrants the statement that under-nourishment is a predisposing cause of tuberculosis.' Chalke refers to the abnormally high death-rate in certain parts of North Wales and emphasizes the aetiological importance of depleted diet by lowering bodily resistance. He found that the deficiency in diet in the district he investigated was mainly in regard to milk, fresh meat, fruits, and vegetables.

This accepted conclusion opens up a wide field for speculation as to the manner in which a diet deficient in certain constituents paves the way for the disease. The fact that a deficiency of milk appears to be more important as a factor predisposing to tuberculosis than a deficiency in other foodstuffs suggests that the inadequate intake of vitamins, especially vitamins A and D and of calcium salts, may be the explanation. It should be possible to prove experimentally whether an animal deprived of these essential constituents tends to become more susceptible to infection with measured doses of tubercle bacilli than controls, or conversely that an animal fed on a diet rich in these constituents displays

greater resistance to a measured dose. It is an accepted fact that vitamin A is necessary to the integrity of the epithelial layer of the respiratory and gastro-intestinal tracts, and it is recognized that one effect of the inhalation of silica dust which predisposes to tuberculosis of the lungs is the desquamation of ciliated epithelium of the bronchioli to which it gives rise. Vitamin D is necessary for the normal growth of bone, to calcium balance and to normal dentition. Does lack of vitamin D make the bones and joints of a growing child more susceptible to infection? Sir Frederick Hopkins has advanced the view that vitamins are exogenous hormones and this conception opens a wider field of speculation regarding the character of the metabolic changes which may govern resistance or impaired resistance to tuberculous infection.

IMPAIRED RESISTANCE. The individual who although exposed to infection, escapes the development of clinical manifestations of the disease possesses a natural or specific resistance. Such resistance in a large percentage of individuals is only partial, as it may break down under the influence of adverse factors or conditions. It may also be complete against a minimal dose of infection, but prove ineffectual against a medium or maximal dose. The balance between resistance and progressive infection is a delicate one and as experience has shown, it is readily upset by the intrusion of adverse influences and conditions.

The factors which impair resistance to infection are many and varied, and they may act singly or in combination. They exercise their influence by impairing generally the defensive mechanism of the body or by a local impairment of some special structure or organ.

Overcrowding and unhealthy home conditions have been proved to be associated with a high incidence of tuberculosis. They lower the standard of general health, increase the risk of contact infection, and exercise some unknown adverse influence by the organic pollution to which they give rise. The subject is more fully discussed in a subsequent chapter.

Trauma is responsible for the breakdown of local resistance to infection. According to the law of Schultze, if trauma is present organisms circulating in the blood-stream will become localized at the point of injury. A history of injury is not infrequently obtained in cases of tuberculosis of bones and joints. Injuries

to the chest walls and lungs may also be the determining factor in tuberculosis of the lungs, as was pointed out by Parkes Weber and was proved during the War. The development of progressive tuberculosis as a sequela to silicosis is an illustration of the disease following fine but widespread trauma of the lungs. Trauma may also activate existing foci of disease. Parkes Weber had pointed out that latent tuberculous lesions may be so compressed or strained in consequence of trauma that tubercle bacilli are disseminated over normal lung tissue. Pagel and MacCallum describe a case which supports this view, that of a man with chronic pulmonary tuberculosis who was killed in a motor accident. The autopsy showed the partial destruction of old caseous and calcifying lesions and their replacement by red blood corpuscles.

INDUSTRIAL CONDITIONS. These predispose to infection owing to the adverse influence which they may exercise on general or local resistance. Occupations which are associated with dust, fatigue, and the absence of fresh air and sunlight are especially liable to predispose to infection. With reference to the general influence of industrialism on the incidence of tuberculosis Collis has stated, 'In a European non-industrialized community wherein the disease is endemic, the age of maximum incidence is found late in life. When the habits and customs of such a community are disturbed by industrialism the age of maximum incidence moves to early adult life. As such a community settles down to the new conditions the age of maximum incidence steadily recedes again to later life.'

The occupations which chiefly predispose to tuberculosis are those which are associated with inorganic dust and which, owing to the traumatic changes to which they give rise in the lungs, encourage the retention of tubercle bacilli and impair local resistance. The table opposite gives comparative figures for various occupations.

These figures demonstrate the causative relationship between dusty occupations and the incidence of respiratory tuberculosis. The high figure for barmen is explained by the unhygienic conditions associated with their occupation and the adverse influence of chronic alcoholism.

The association of tuberculosis with silicosis has received much attention. A special study of the subject has been made in South

Comparative Mortality Figures for Respiratory Tuberculosis of Males, aged 20–65, engaged in Certain Occupations, 1921–1923. Comparative Figure, 163·5

Minimum		Maximum	
Building Foremen and Gangers	36·1	Earthenware China: Kiln- and Oven-workers	366·8
Barristers	40·4	Costermongers	374·2
Farm Bailiffs and Foremen	40·4	Hawkers and Street-sellers; Cutlers	387·9
Ministers, not R.C. or C. of E.	42·2	Drafters and Brushmakers	388·5
Bank Officials	47·5	File-cutters	399·3
Ministers, C. of E.	52·5	Barmen	439·9
Insurance Officials	58·4	Potters, Mill-workers, Slipmakers	499·6
Farmers and their relatives	67·7	Slatemakers and Slate-workers	560·1
Coal-mine Subordinate Superintending Staff	70·5	Metal Grinders	695·9
Foremen Woodworkers	71·2	Grinders in cutlery trade	1,288·0
Registered Medical Practitioners	75·6	Tin- and Copper-miners	1,446·5
Railway Signalmen	75·8	Tin and Copper Underground-workers	2,061·3

Africa by Simpson, Strachan, and Irvine. The authors describe the clinical, X-ray, and post-mortem features of four types of the condition: namely, simple non-tuberculous silicosis, simultaneous tuberculosis and silicosis, silicosis preceded by tuberculosis, and silicosis superimposed upon tuberculosis. The differential pathological features of these various types are clearly described. In simple non-infective silicosis fibroid foci develop which increase in size and finally coalesce. The X-ray picture is one of increase in density of the pulmonary tree with progressive mottling. In simultaneous tuberculosis and silicosis the fibroid foci develop more rapidly and show necrotic changes in their centre. When silicosis is preceded by tuberculosis the fibroid nodules are more isolated and less symmetrical. In cases in which tuberculous infection develops subsequent to silicosis the fibroid nodules are found to be surrounded by areas of caseation. The X-ray picture of tuberculosis shows increased clouding and blurring of the shadows produced by silicosis. It has been pointed out by Middleton that when dust contains a high percentage of free silica and is in a fine state of division, silicosis tends to develop rapidly. This type is met with in grinding, sand-blasting, and abrasive soap manufacture. When the dust is of more moderate concentration the disease develops more slowly and this type is found in metal-grinders and in sandstone and pottery workers. When dust contains silicates the results vary in severity and the most severe type met with is produced by asbestos. Middleton states that the fibrotic changes produced in the lungs by free silica differ from those produced by silicates, and that it is possible to distinguish them radiologically and histologically.

The actual relationship of silica dust to pulmonary tuberculosis has been accurately established. The effect of the fine dust is to block the lymph channels, produce desquamation of epithelium, and so facilitate the entrance and retention of tubercle bacilli in the lungs. The dust is the pioneer which prepares the way for the following bacteria. Infection is facilitated by a high degree of humidity of the air which tends to prolong the life of the tubercle bacillus and encourages aerogenous invasion.

Some interesting experimental work on the relationship between silicosis and pulmonary tuberculosis has been carried out in the

Saranac Laboratory for the study of tuberculosis in the United States. It has been found that both the crystalline and amorphous form of silica produced the well-marked fibrotic changes characteristic of silicosis, and that in animals with partially healed tuberculous lesions the inhalation of silica dust leads to a reactivation of the disease; non-infected silicotic animals were also found to be extremely susceptible to primary infection by artificial inoculation.

A parallel condition to silicosis as a predisposing factor to tuberculous infection of the lung is that of asbestosis. The asbestos dust which is inhaled contains in addition to silicates asbestos particles in the form of fine fibres which are caught in the respiratory bronchioles and the alveolar ducts, and a considerable percentage of ferrous iron. Gloyne states that it is not yet known what tissue reaction should be attributed to the different parts of which asbestos is composed. In all types of silicosis apart from the character of the particles inhaled, the activity of tuberculous lesions in the pulmonary tissue must vary according to whether the infection with tubercle bacilli occurred previous to, was associated with, or was subsequent to, dust inhalation of sufficient intensity and duration to produce the characteristic fibrotic changes in the lung. Wood and Gloyne, in a series of fifty-seven cases of pulmonary asbestosis, found twelve cases of pulmonary tuberculosis, in ten of which the disease was active and three of which terminated fatally. These observers incline to the view that the more frequent occurrence is for a tuberculous infection to be superimposed on a commencing pulmonary asbestosis.

The virulence of the tuberculous infection associated with silicosis varies within considerable limits, depending as it does on the type and concentration of silica dust, the dose and type of infection, and other factors. In the writer's experience, thirty years ago, in the North of England, the most active and progressive type of infection was observed in workers in the powder department of the soap industry, although here the influence of massive contact infection was possibly equally responsible for the acute character of the disease. The following tables give information as to the average age at death, and duration of employment, in workers in various industries which give rise to silicosis investigated by the Home Office since 1929.

	Number of Deaths	Average Age at Death	Duration of Employment in Years		
			Longest	Shortest	Average
Silicosis . . .	375	55·7	62·0	1·7	34·8
with Tuberculosis	453	52·6	67·0	2·0	31·4
Asbestosis . . .	59	42·8	36·0	1·5	13·3
with Tuberculosis	34	37·2	29·0	0·8	9·4

Industry	Number of Deaths	Average Age at Death	Duration of Employment in Years		
			Longest	Shortest	Average
Pottery:					
Silicosis . . .	181	57·9	62·0	2·8	39·1
with Tuberculosis	186	54·5	67·0	5·0	36·2
Sandstone:					
Silicosis . . .	92	56·2	57·0	9·0	38·2
with Tuberculosis	104	53·9	53·0	5·0	35·2
Grinding of Metals:					
Silicosis . . .	40	56·4	56·0	18·0	35·8
with Tuberculosis	82	51·7	52·0	2·8	30·9
Sandblasting:					
Silicosis . . .	20	45·4	24·0	1·7	11·5
with Tuberculosis	43	45·0	28·0	2·0	9·4
Manufacture of Scouring Powders:					
Silicosis . . .	10	35·2	37·0	2·3	8·9
with Tuberculosis	2	33·5	10·8	2·0	6·
Miscellaneous:					
Silicosis . . .	32	53·8	45·0	6·0	22·0
with Tuberculosis	36	50·9	50·0	7·0	25·4

In females the influence of industrialism in relation to tuberculosis is necessarily less marked than in males, although its effect can be recognized in the young adult age group in industrial districts. The most frequent occupation of females in the less industrialized areas who have developed tuberculosis is that of housewife, in regard to whom the adverse influence of undernourishment, large families, and unhealthy home conditions have to be taken into account. The housewife spends a large proportion of her time in the home and with her young children under the age of five is more exposed to home infection than other members of the family. In the table on page 58 particulars are given of the occupations of 1,274 female patients with positive sputum in the county of Hertford.

Included in other occupations in this table are females not occupied and school-children, the figures for these being 57 and 25 respectively; in no other occupation did the figures exceed five.

MENTAL AND PHYSICAL STRAIN. In addition to actual trauma resistance to tuberculosis is impaired by mental and physical strain. The neurasthenia which is the result of mental strain and anxiety predisposes to infection, although neurasthenic symptoms may also be the expression of chronic toxaemia of tuberculous origin. Prolonged or excessive mental effort and industrial fatigue are liable to wear down a protective resistance to clinical manifestations of infection. Emerson attaches much importance to over-fatigue as a cause of malnutrition in children and consequently as an important determining factor in the incidence of tuberculosis. In the report of the Ministry of Health on Tuberculosis in Wales reference is made to the possible influence of stress or strain in increasing the injurious results of dietary deficiency, or in causing them to appear in persons who previously had shown no evidence of such deficiency. Excessive physical strain has been found to be the precipitating factor in certain cases of the disease. Burton-Fanning found in 10 per cent of his patients a correlation between excessive physical strain and the development of tuberculosis. The writer has also met examples of this in sprinters and swimmers. In one such case, that of a finely developed apparently healthy sprinter, the disease was a rapidly fatal miliary tuberculosis, as

Occupations	Age Groups					State		
	5–10	10–20	20–30	30–40	40 +	Married	Single	Total
Housewife . .	—	3	174	210	163	550	—	550
Domestic . .	—	43	85	35	27	30	160	190
Factory-worker .	—	59	107	16	3	13	172	185
Clerk . . .	—	21	67	12	4	6	98	104
Shop Assistant .	—	23	25	6	6	4	56	60
Nurse . . .	—	5	9	16	6	4	32	36
Laundress . .	—	3	17	4	5	6	23	29
Teacher . . .	—	—	9	4	5	—	18	18
Other occupations .	5	39	34	13	11	11	91	102
Total .	5	196	527	316	230	624	650	1,274

was proved by post-mortem examination. In such cases the effect of local trauma due to excessive strain on a quiescent existing focus of disease is the most likely explanation of the sudden and unexpected exacerbation.

THE INFLUENCE OF ASSOCIATED DISEASE. The balance of resistance to tuberculosis may be disturbed by the adverse influence of some other disease, but the extent and character of this influence is obviously difficult to estimate. Mental disturbance and defect, and acute and chronic conditions of disease make a demand upon the protective and reserve forces of the body which varies according to the intensity, duration, and character of the disease, and the organ or structure chiefly involved.

The acute infections, with the exception of influenza, do not appear to exercise much influence in determining the development of tuberculosis. A history of influenza preceding the development of tuberculosis is fairly frequently obtained. It is true that the constitutional disturbance diagnosed as influenza may be the expression of the exacerbation of an existing tuberculous infection. Sir Arthur MacNalty refers to the fact that in this country there is an increase in the number of deaths attributed to pulmonary tuberculosis during epidemics of influenza. He points out that the peak of the death-rate from tuberculosis coincides with the peak of influenza mortality, which indicates that the increase is due to influenza and not to any exacerbation of tuberculosis, and that the explanation is probably to be found in a higher mortality from influenza among tuberculous subjects than in the general population. One would have expected that the marked general debility which not infrequently follows influenza would have seriously impaired resistance to tuberculous infection, and clinical evidence tends to support this view.

The possible aetiological relationship between the various acute diseases and tuberculosis has been investigated by McKinlay and Watt in a series of children. These observers obtained no definite evidence to support the view that such diseases as measles, scarlet fever, diphtheria, whooping cough, chicken-pox, pneumonia, and bronchitis were likely to induce any impaired resistance to tuberculous infection. They found, however, that the incidence of all these diseases was slightly higher among those who became

ultimately tuberculous than among controls, but the difference was insignificant, except in the case of scarlet fever, which showed a percentage of 18·6, compared with 7·2 for controls. Westwater followed up the history after the age of fifteen, of thirty-four children positive to tuberculin, who had had measles and found no evidence of tuberculosis, but in such cases the presence of specific protection would have to be taken into account. Although there exist no substantial data to support the view that measles predisposes to tuberculosis, some observers are of opinion that the allergic condition which follows measles is likely to increase liability to tuberculous infection. A similar condition has been postulated as a sequela of whooping-cough, but there is no definite proof that this disease predisposes to tuberculosis. The fine bronchitis or broncho-pneumonia which so frequently complicates attacks of measles and whooping-cough would no doubt tend to exacerbate an existing tuberculous focus in the lungs, but they do not appear to impair local resistance to infection, notwithstanding the added risk of some degree of trauma in connexion with whooping-cough.

Certain diseased conditions, by the adverse influence which they exercise on the general health and protective mechanism, predispose to tuberculous infection or tend to encourage exacerbation when it is present. Before the days of insulin treatment the diabetic subject who developed tuberculosis was found to offer poor resistance to the progress of the disease, which was rapidly fatal. Alcoholism also impairs resistance to tuberculosis, and when associated with the disease gravely affects the prospects of recovery, although if the alcohol is restricted to beer the effect is less injurious. When the wage-earner is addicted to alcoholic excess the dependants are likely to suffer from poverty and privation and become much more susceptible to infection. The development of cirrhosis of the liver in chronic alcoholics undoubtedly increases the liability to tuberculosis, especially of the peritoneum and pleura. Syphilis is generally accepted as impairing resistance to tuberculosis; various observers, including Emile Sergent have brought forward evidence in support of this view. Rickets is stated by some authorities to predispose to pulmonary tuberculosis in later years by the mechanical restriction of apical expansion which results from the osseous changes to

which it gives rise. In rickety children, however, nutritional and other factors have to be taken into consideration as possible contributory causes.

Mental disorder and mental deficiency of low-grade type impair resistance to tuberculosis, while the habits of mental patients increase the incidence of abdominal infection. Tuberculosis is a frequent terminal infection in mental defectives. The slow movement, relaxed posturing, shallow breathing, sluggish circulation, and general subnormal physical condition of the mental defective are associated with a definite impairment of resistance to tuberculosis. From an investigation into the death-rate from tuberculosis in a large mental hospital by A. Elkins and the writer, it was found that the death-rate per 1,000 varied from 18·5 in 1911 to a maximum of 117·6 per 1,000 in 1918. Petrie has stated that in the case of schizophrenics there is undoubtedly a lowered resistance to tuberculosis, and that their habits and tendencies predispose to infection. He submits statistical evidence in support of this view and quotes the figures of Ostmann which show that of 790 deaths from tuberculosis in mental hospitals 429 occurred in schizophrenics. Petrie also refers to a fact of significant interest, namely, that the children and siblings of schizophrenics, even when non-psychotic, show impaired resistance to tuberculous infection. This no doubt provides an explanation of increased susceptibility in certain families. According to evidence submitted by Mott much of the infection in patients in mental hospitals existed in latent form before admission, and the fact that it is much more difficult to carry out personal preventive measures in connexion with mentally disordered and defective persons necessarily tends to facilitate the spread of the disease unless the most stringent precautionary measures are adopted.

A study of the incidence of tuberculosis in these mentally subnormal groups raises points of epidemiological interest. It emphasizes the existence of a specific predisposing factor which in times of special stress and strain may have wider implications. It presents also the illustration of a special subnormal group with a ratio of susceptibles, or at least of individuals possessing less than normal resistance, living under institutional conditions. If to such conditions there should be added other predisposing factors,

such as inadequate intake of food, overcrowding, and a lowering of the hygienic standard, the reasons for a progressive increase in the incidence of tuberculosis in these groups become obvious.

COMBINED PREDISPOSING FACTORS. It is difficult to estimate the relative importance of the various factors which predispose to tuberculous infection as frequently they exist and exercise their influence in combination. This is well illustrated by the results of Bradbury's Tyneside investigation. An individual who lives in an overcrowded, insanitary home, follows an occupation associated with inorganic dust, and is addicted to alcoholic excess comes under the adverse influence of a three-fold predisposing factor. Similarly, a woman who in addition to industrial strain lives under unhealthy conditions and has a diet deficient in fats, proteins, and vitamins, has to face a three-fold attack upon her protective mechanism against infection. It is the existence of numerous factors which singly and collectively wear down natural or specific resistance to active tuberculous disease which renders more difficult the problem of prevention and complete control, and which in the presence of any lowering of the social standard of life will tend to increase the incidence of the disease.

THE TUBERCLE BACILLUS. This organism, discovered by Koch in 1882, was proved by him to be the immediate cause of tuberculosis. Its various types and its relationship to tuberculous lesions in man and in animals have been extensively studied, and we have now a fairly accurate conception of its parasitic life in human and animal hosts. Of its life-cycle apart from its parasitic existence we know little, but it is quite impossible to envisage an organism of this type with its waxy protective envelope as having no cycle of existence outside a living host. But although the tubercle bacillus is more resistant than the majority of known organisms, it is readily destroyed by antiseptics, by direct sunlight, and by ultra-violet radiations. It will, however, survive for considerable periods if such conditions as moisture, organic impurities, and the absence of sunlight exist.

The tubercle bacillus belongs to a group of acid-fast organisms which are widely distributed and which are either parasitic to man and animals or have a saprophytic existence.

Morphologically the bacillus presents the appearance of a small

rod which may be short and blunt or slender and elongated; it is alcohol-fast and non-motile. Certain aberrant forms of the bacillus, including the granular form known as Much's granules, which are non-acid-fast, have been described. The mature bacillus presents certain unstained areas which are considered to be vacuoles; it is readily stained by Gram's method, but for routine examination the Ziehl-Neelsen stain is the one universally employed.

The morphological features of the tubercle bacillus present an interesting study. Its long slender and short compact shapes and its aggregation in clumps, as seen in positive sputum, are well known. According to some observers, however, it also occurs in much smaller and less easily identified forms which have given rise to the view that associated with the actual bacillary form of the organism there exists a virus of filtrable character. Fontes, Calmette, and other investigators believe that in one phase of its life-cycle the tubercle bacillus exists in the form of minute granules which constitute a filtrable virus. The subject has recently been investigated by Fraenkel and Pulvertaft. They employed a strain 'bovine vallee', which was obtained from the Institut Pasteur, and which was stated to contain a filtrable virus. They obtained some positive results from floating cultures of the strain; seven positive results after filtration through membrane filter 0·75μ, three positive results after passing through L_2 candles, and two positive results with membrane filter 0·3μ. The method adopted was inoculation into the lymphatic glands of the neck of the guinea-pig, and the variation in the results obtained is interesting and suggestive. In some cases tuberculous lesions in the infected gland with large nodules in the spleen were produced; in others enlargement of the gland without or with very few acid-fast bacilli. The presence of tubercle bacilli in the lymphatic gland when not otherwise identified was occasionally demonstrated by culture on Loewenstein medium, or by inoculation into another guinea-pig with a consequent generalized tuberculosis. In a further investigation the same observers tested the filtrable character of eight strains of tubercle bacilli and obtained positive results in four of these. They conclude from the results obtained that the filtrability of these strains is probably due to the presence of immature bacilli or granules, and they found no

evidence to support the view that there exists associated with the tubercle bacillus a distinct ultra-visible virus which produces a distinct type of the bacillus.

An interesting possibility as to the significance of these filtrated granules has been suggested by the observations of Kahn, who studied the life-cycle of the single organisms isolated from a stock culture of the human type of bacillus with a view to determine its method of reproduction. He found that in addition to simple fission the tubercle bacillus adopts a much more complicated process of reproduction characterized by curious pleomorphic features. His findings he summarized as follows: (*a*) Initial segmentation of the tubercle bacillus into three or more ovoid units, (*b*) the division of these units into diplococcoid forms, (*c*) the grouping of these elements into a mass of minute particles from which extremely small and delicate rods were observed to sprout, and (*d*) the subsequent development of these tiny rods into mature tubercle bacilli. At certain stages of this developmentary process the organism was found to be non-acid-fast. The morphological variations of the tubercle bacillus which have been demonstrated by these and other observers raise interesting speculative problems regarding their aetiological relationship to the disease. If products of the tubercle bacillus exist as filtrable granules or immature bodies, their existence in blood, sputum, pus, discharge, milk, both human and bovine, must be postulated, and these granules, owing to ultra-visibility or absence of acid-fast characteristics, cannot be recognized by ordinary microscopic examination, but require for the ultimate detection prolonged and elaborate cultural and biological methods. It has been stated that these aberrant types of the organism are capable of producing in inoculated animals tuberculous lesions in which the mature type of bacillus is ultimately found. There is the obvious possibility that these variants may have some part in the production of contact infection and in relation to the intensity or latency of a primary or secondary infection, but as this is purely speculative it is not possible to discuss it further in the light of present knowledge. It should be stated, moreover, that a series of experiments carried out by Gloyne, Glover, and Griffith, to determine whether there exists a filtrable form of the tubercle bacillus, proved negative, and none of the animals

colonies of the smooth strain are circular and convex with a smooth surface and entire edge, while those of the rough strain are irregular in outline and heaped up with a rough granular surface. Morphologically also there is a distinction; the bacilli comprising the smooth strain are fairly long, curved, sometimes beaded, and are seen more or less parallel and in bundles, while those in the rough strain are short, sometimes ovoid or coccoid in shape, and appear in Chinese letter forms or in dense clumps. The authors point out that these distinctive features are due to a different method of division, for whereas in the smooth strain the division is complete and the bacilli occupy a separate position in parallel rows, in the rough strain the division is not complete, but angular, resembling a greenstick fracture, and the bacilli occupy masses which become heaped up. The authors further state that it is not possible to say to what extent these two strains vary in virulence, but if we accept the view, which appears to be the most reasonable explanation, that the younger the strain the more severe the infection, it would appear that the rough strain would, if similarly produced in the human host, constitute the more virulent infection. J. E. Pottenger carried out an extensive investigation, comprising some eight thousand observations, regarding the correlation between the length of the tubercle bacillus and the degree of activity of the disease, and the result of his observations indicated that the short forms predominated during greater activity and acute phases of the disease, and the long or more mature forms were associated with lessened activity and with chronicity.

The degree of virulence of an infection must necessarily depend to a large extent upon the mass of dosage or the actual number of tubercle bacilli which primarily invade an unprotected host. A massive dosage or rapidly repeated small doses will tend to produce an infection which is progressive or becomes generalized. Small doses, however, in the case of susceptible animals have been proved to be potent in giving rise to a progressive and fatal infection. Schwabacher and Wilson have carried out a series of experiments with a view to determine whether by the employment of minimal doses of tubercle bacilli it were possible to induce a chronic self-restricted retrogressive form of tuberculosis. They employed by intra-muscular inoculation a dose which was

estimated to represent two to ten living bacilli. While the local lesions produced by minimal doses tended to retrogress, the lesions which developed in the spleen, liver, and lungs appeared to be progressive and ultimately fatal. The intra-tracheal or intra-pulmonary inoculation of ten to fifty living organisms produced severe pulmonary lesions which were rapidly fatal with a varying degree of systemic infection. In these experiments both the human and bovine type of bacillus and animals of varying susceptibility were used and the investigators remark that 'even when minimal numbers were given, the disease, once it was established, appeared to be progressive and to lead eventually to a fatal issue'. These results would appear to indicate that the progressive infection is not so much a question of amount of dosage as the absence of resistive capacity against the active development of infection from what may be a minimal number of tubercle bacilli which have gained entrance. Burrell had pointed out that in human beings, as in animals, the measure of the dose which proves fatal bears some relationship to the weight of an animal, so that a dose sufficient to prove fatal to an infant could be resisted by an adult. It is not, however, so much the number which invade, but the rate of increase after invasion has taken place which is the significant factor, while virulence of strain must be viewed in relation to an impaired or absent protective resistance.

METHODS OF INFECTION. The most frequent methods by which primary infection takes place in the human subject are by inhalation and ingestion. The former method largely predominates, and infection by inhalation may be induced through the medium of infected droplets or dust. Droplet infection is regarded as the method of communication in cases of close contact, such as occurs in the case of a tuberculous mother nursing a young child. Experiments have shown that direct droplet infection is only possible when proximity to the infected person is within three or four feet, the distance over which infected droplets can be propelled by the patient during coughing, sneezing, and loud talking. Infected droplets after expulsion, unless they come into contact with individuals or articles of furniture, remain suspended in the air until they slowly gravitate to the floor, where in time the moisture evaporates and the bacilli

are set free to mingle with the dust. Dust particles containing organisms are easily disturbed by movements and currents of air in a room, and may circulate considerable distances and at considerable heights. It has been proved that the dust from an infected room contains tubercle bacilli, and these will survive for some considerable time if favourable conditions such as darkness, warmth, and moisture are present. The fact that the dust of rooms occupied by patients suffering from open pulmonary tuberculosis contains tubercle bacilli has been proved by various observers. Cornet in 1888 inoculated guinea-pigs with dust obtained from rooms and workshops occupied by such patients and obtained a positive result in 20 per cent of cases. Positive results were also obtained from dust taken from general and mental hospitals, the results being 21·3 and 39·4 per cent respectively. Tubercle bacilli have also been found to be present in the dust of railway-carriages and tramcars, but it is significant that they are seldom recovered from the dust of sanatoria and tuberculosis hospitals.

While droplet infection is the chief method by which the disease is transmitted, where there is close contact, dust infection also plays an important part. When infection is contracted in the office or workshop it is frequently through the medium of infected dust.

The third method of infection is through the medium of milk containing tubercle bacilli, and is the one chiefly responsible for the development of abdominal and other extra-pulmonary forms of tuberculosis in young children.

While milk is the chief medium of infection by ingestion, tubercle bacilli may be present in butter, cream, cheese, and other forms of milk foods. Tubercle bacilli may also be present in meat, but the risk of infection from this source is regarded as slight, owing to cooking and to the inspection which is carried out.

The possibility of some other method of infection cannot, however, be altogether excluded. It is difficult to envisage all individuals who are positive reactors as being infected by one of the three recognized methods. The tubercle bacillus is so closely associated with man in his urban existence that the relationship between the parasite and the host presents a diverse problem many

aspects of which have not yet been elucidated. One of these is the frequency with which reactive but non-clinical infection occurs without any overt contact with clinical cases of the disease. The occurrence of cases of masked infection or latency does not altogether explain the high ratio of positive reactors: is the occurrence of mutation the true explanation?

PATHS OF INFECTION. As has previously been stated, congenital tuberculosis occasionally occurs as a result of pre-natal infection. Some French authorities hold the view that primary infection in the human subject occurs in utero and is the result of the passage through the placenta of the granular elements of tubercle bacilli which subsequently develop into the mature organisms. This conception of the origin of primary infection is not, however, accepted in this country, and so far no concrete evidence in support of it has been submitted.

The most frequent path of infection is by the respiratory tract, resulting in the development of a pulmonary lesion; it is estimated that at least 80 per cent of primary infections are aerogenous in origin. A primary focus may also occur in the tonsil or in the cervical lymphatic glands from aerogenous infection. Aerogenous infection is chiefly due to the human type of bacillus, but the bovine type may also be responsible. The tubercle bacillus also finds an entrance to the human body by ingestion with milk or other food through the intestinal mucosa and gives rise to abdominal infection; the resulting lesions occurring in the abdominal lymph glands or involving the peritoneum. These lesions are frequently due to the bovine type, while gross intestinal lesions are usually the result of secondary endogenous infection with bacilli of the human type. A circuitous path for pulmonary infection by ingestion is via the lacteals, thoracic duct, superior vena cava, and right heart to the lungs, and this no doubt accounts for some cases of pulmonary tuberculosis due to the bovine type of bacillus. There is increasing evidence to support the view that bacilli introduced via the gastro-intestinal tract will produce a primary pulmonary infection.

Direct infection of the skin and mucous membranes also takes place. The post-mortem wart and the superficial infection sometimes observed in butchers are examples of infection through direct inoculation. The high percentage of bovine infection

found in cases of lupus is somewhat remarkable, as the majority of such cases appear to have no connexion with cattle.

PRIMARY INFECTION. It is now generally accepted that the primary infection in human tuberculosis takes place in the majority of cases in the pulmonary tissue and during the early years of life. Blacklock in his series of cases found that the primary focus occurred in the lung in 85·5 per cent. The length of the incubation period in the human subject is not accurately known, although it may extend to several months; in animals the incubation period of experimental infection is short—a week to ten days. To what extent the period of incubation varies in duration according the severity of infection, dosage, and diminished resistance is unknown. Debre and Jacquet refer to the ante-allergic period which represents the time which elapses between actual contact and the development of a positive response to tuberculin. This period has been found by different observers to vary considerably in duration; the maximum being six months and the minimum about one month. This ante-allergic period would coincide with the period of incubation, but it must obviously be extremely difficult to determine its duration. The true period of incubation must be the time which elapses between the settlement of tubercle bacilli in the selected tissue and the formation of true tuberculous tissue under the stimulus of the toxins of the organism. If the tissues invaded permit of elaboration of toxic products of the bacillus with the consequent formation of a tuberculous focus the allergic state is established.

The term allergy is applied to the reactive state of the body induced by infection, which is permanent but variable in degree, and which according to this variation may show as responsive phenomena, sensitiveness, insensitiveness, or an immunity response. The significance of allergy and its relationship to a correct conception of specific prevention and treatment have been clearly presented by Lyle Cummins in a communication from which the following conclusions are taken:

(1) The response of man to tuberculous infection exhibits three constitutional states: (*a*) indifference which is pre-allergic, (*b*) intolerance, and (*c*) tolerance; the two latter depending on the acquired character of allergy and reinfection. Allergy or

altered reactivity manifests itself in tuberculosis in a series of states which may be sub-divided as follows: (*a*) hypersensitivity represented by toxic and inflammatory processes as expressed by such symptoms as fever, rapid pulse, loss of weight, pallor, and by local tissue reaction; (*b*) allergic immunity, which is the immune response evoked by the toxic products of the bacillus and which results in a remission in the active progress of the disease, and (*c*) augmentation of the natural immunity which promotes spontaneous healing. In connexion with the protective influence of a primary infection, Wingfield states that the net result of the average primary infection is a negligible primary lesion with involvement of the lymphatic system by which the infection is safely held. He considers that the partial active immunity produced by the primary infection has as its most important function the fixing of the infecting virus.

The first reaction of the tissues to tubercle bacilli in a susceptible subject is a mechanical reaction, and is non-specific in character; subsequently the formation of tubercles containing the characteristic epitheloid and giant cells takes place. The invading bacilli may, however, remain in the tissues without elaborating toxic products or producing any tissue changes. The ultimate fate of the primary focus of infection is varied and depends upon the resistance offered to its development and other factors. As autopsy records have shown, it may eventually heal and be replaced by healthy scar formation. In such cases there is added to a high degree of natural resistance an acquired specific immunity response which is likely under normal conditions to confer immunity throughout life. The focus may not actually heal but remain quiescent or latent with living tubercle bacilli embedded in its tissue which at some future date may become active and virulent and give rise to an expanding lesion or to fresh foci of infection elsewhere. Or the primary focus may develop and extend by slow progression with phases of relative quiescence and ultimately prove fatal after a considerable period of time. Finally, the primary infection may prove rapidly fatal from generalized tuberculosis due to systemic infection or as a result of some specially vital part, such as meninges, becoming involved.

In primary infection of the lungs certain sites of selection have

come to be recognized. The primary lesion was first described by Parrot in 1876 as a single focus located in the sub-pleural tissue and which showed no progressive tendency. In pulmonary infection in children the initial lesion is also known as Ghon's primary focus, which is a circular lesion of small size usually appearing in the lower lobe. In the adult, more especially the young adult, the primary pulmonary focus is now generally known as Assmann's focus. The character and significance of this focus have been described by Assmann, Redeker, Arborelius, Kerley, and other observers. Kerley states that the radiographical picture of this focus shows a small round opacity varying in size from that of a pea to half a crown located in the right infra-clavicular region. It is also occasionally observed in the right middle and lower lobes and in the left infra-clavicular region, but rarely if ever in the left lower lobe. One feature of this focus is the zone of what appears to be inflammatory reaction which frequently surrounds it. The nature of this zone of reaction is not quite clear, but it is probably due to the fact that the central tuberculous focus is a primary infection which gives rise to a local tissue reaction. This association of non-specific reactive disturbance with active tuberculous lesions has long been recognized clinically. In common with both these primary foci the lymphatic glands which drain the locations involved become infected by passage of the tubercle bacilli along the lymph channels; this is known as the Law of Parrot. It is generally accepted that both Ghon's and Assmann's foci are the result of an exogenous infection through the respiratory tract. Blacklock found in his investigation that where the primary focus was found in the lungs only tubercle bacilli of human origin were obtained. It does not follow, however, that all cases of primary lung infection are due to aerogenous infection. Pottenger emphasizes the point that no matter where the tubercle bacilli are introduced some of them will finally find their way through the lymph and blood-streams to the lungs, and that this is especially liable to occur in the pre-allergic state before the reactive response has been elicited.

In primary abdominal infection the primary focus may occur in the intestinal wall, but more generally the primary infection develops in the mesenteric glands or in the peritoneum.

REINFECTION. In the human subject reinfection by tubercle bacilli may be exogenous or endogenous, the former being a fresh infection from without and the latter a fresh infection of new tissue by tubercle bacilli from an existing focus in the human body. All cases of primary infection are necessarily exogenous, and there is an increasing tendency to regard the majority of cases of reinfection as endogenous in origin. In exogenous reinfection the tubercle bacilli causing the reinfection may be of a different strain, or even of a different type to those responsible for the existing primary infection, although an individual with a primary infection may presumably reinfect himself with his own strain from without. The allergic immune response is more active in relation to an exogenous than to an endogenous reinfection. Endogenous reinfection may be induced in several ways. There may be a direct extension of the primary lesions so as to involve contiguous normal tissue. The development of lesions distinct and separate from the primary focus may result from the passage of tubercle bacilli through the lymph channels, and the blood-stream. Lastly, a pulmonary reinfection may be broncho-genetic in origin, arising from the aspiration of infected material from an old primary focus in the lung.

The reason why the pulmonary tissue is the most frequent seat of secondary infection has frequently been investigated. The fact that the lungs receive blood from all parts of the body must necessarily increase the risk of pulmonary infection, while the added risk of broncho-genetic infection has to be taken into account. The possibility of the lung tissue being more susceptible to attack by tubercle bacilli than other parts of the body at certain periods of life has also to be considered. Pagel has investigated the question of lung susceptibility by means of animal experimentation. He found that intra-tracheal inoculations with cultures of human strain from sputum produced in normal animals not protected, slight pulmonary lesions at the base which persisted or disappeared. An intra-trachael inoculation of virulent strain in a non-protected animal produced small basal foci in the lungs and progressive small lesions in the kidneys and spleen. He found that in animals reinfected with a virulent strain there was produced a tuberculous infection confined almost entirely to the lungs with slight deposits in the kidneys, whereas in susceptible

controls a corresponding infection produced extensive tuberculosis of the lungs, kidneys, spleen, and liver, and this difference he attributed to some degree of allergic protection in the infected animal. Pagel's conclusion from his experiments is as follows: 'Since isolation of the tuberculous process in the lungs is the most striking feature of the adult type of human pulmonary tuberculosis, the results of these experiments point to the conclusion that isolated pulmonary tuberculosis in the adult is dependent upon the peculiar allergic condition of an incomplete immunity which suffices for the protection of the extra-pulmonary organs, but not of the most susceptible of the organs, the lungs.'

Although there exists experimental and clinical evidence to support the view that a primary infection of a certain degree of potency if it has healed confers protection against reinfection, it is evident that this protection in the human subject is by no means complete and, moreover, may be seriously impaired or almost completely annulled by adverse factors.

The relationship between primary infection of bovine origin in children and reinfection is less easily understood. Some authorities consider that a primary infection with the bovine type of organism gives an increased protection to infection with the human type of bacillus, and there is some evidence in support of this view. A secondary endogenous infection of the lungs in a person primarily infected with bacilli of bovine origin would be due to the same type of bacillus, and one would expect to find the bovine type of organism more frequently in adult pulmonary tuberculosis, but apart from the suggestive findings of Monro as to the presence of bovine tubercle bacilli in the tracheo-bronchial glands, there exist no clear data as to the correlation between primary infection of bovine origin and secondary pulmonary endogenous infection.

CONTACT INFECTION. It has been conclusively proved by statistical evidence that the chief cause of the endemic persistence of tuberculosis is contact infection in the home of children under the age of five years. The possibility of contact infection occurring in the school, especially in the residential school, must also be considered. The improvement which has taken place in the hygienic and sanitary standard of public

elementary and secondary schools has no doubt minimized the risk of infection to a large extent, but there is still room for improvement in regard to spacing and ventilation in the dormitories of some of our private residential schools. Infection, when it does occur in the school, is contracted from a pupil or less frequently from a teacher who is suffering from the open type of tuberculosis, while the existence of one or more cases of clinical tuberculosis in the class may be responsible for infection of the teacher.

The problem of contact infection has been studied in relation to the immediate mortality rate caused by the disease, the incidence rate of clinical manifestations and the ratio of reactors among contacts compared with these among non-contacts. The term contact in relation to tuberculosis has been somewhat loosely used, but in most of the investigations carried out in this country with a view to determine the incidence of infection in contacts the term has been accepted as applying to an individual who has been living in close touch with an open case of the disease.

The close association between husband and wife would suggest a high incidence of marital infection, whereas the figures given by various observers are relatively low. Fishberg found both husband and wife tuberculous in only 2·5 per cent of 170 couples in which one or other partner was tuberculous. Haupt's figure for 1,500 couples, one of whom was tuberculous, was 7 per cent, and Mongour's corresponding figure for his series of 440 couples was 4 per cent. It is possible that the non-tuberculous partner develops *pari passu* with the development of the disease in the tuberculous partner, a degree of specific resistance sufficient to provide protection, and that this is the explanation of these relatively low figures.

The mortality rates from tuberculosis in contacts submitted by various observers vary within somewhat extreme limits, but this is explained by the fact that the method employed in estimating the death-rates or in deciding what constitutes an actual contact are not comparable, while conditions which influence incidence and mortality must necessarily vary in different districts.

The following figures by various observers of the percentage mortality from tuberculosis under one year in contacts of sputum,

positive cases are given by Kayne: Frantz (Germany) 16·8, Deutsch-Lederer (Germany) 6·6, Heynsius van den Berg (Holland) 12·3, Lissant Cox 1·7 and 3·2, Turner 5·2, Dorothy Dow and Lloyd 1·8, and Tattersall 2·9. The case mortality of the disease in infants under the age of twelve months is high, varying according to different authorities from 15 to 100 per cent. The younger the infant the more fatal is the infection likely to be. The writer has had recently brought to his notice the death of an infant four months old from miliary tuberculosis whose mother had pulmonary tuberculosis with positive sputum. And yet many children escape infection of sufficient intensity to produce clinical manifestations of the disease, and some may even remain non-reactive notwithstanding close contact with sputum-positive cases. The former fact postulates an immune response from repeated small doses of infection, and the latter the existence of natural immunity in a small percentage of cases.

Investigations as to the incidence of infection in contacts have been carried out by various observers in this country. Lissant Cox and others carried out an extensive survey regarding the fate of young children in tuberculous households. The total number of children who were contacts of persons with positive sputum and whose history was investigated was 1,486, of whom 1,023 were under the age of five years. The number of deaths from pulmonary tuberculosis in contacts under the age of five was five, while the deaths from other forms of tuberculosis numbered forty-five, of which thirty-one were due to meningitis, eight were due to general tuberculosis, and four were due to abdominal infection, the two remaining deaths resulting from tuberculosis of bones and joints and of peripheral glands respectively. The percentage of deaths from tuberculosis of the respiratory system was 3·3, compared with the control figure of 0·6 per cent for England and Wales. The percentage of deaths from other forms of tuberculosis was 30·0, compared with the corresponding control figure of 3·8 per cent for England and Wales. One interesting fact emerges from the results of this investigation. In the total number of children under the age of five years 150 deaths had occurred at the time of the investigation, of which fifty were due to tuberculosis. The percentage ratio of deaths from causes other than tuberculosis, chiefly infectious, was, with the two significant

exceptions of deaths from meningitis not tuberculous and deaths from convulsions, lower than the control ratio for corresponding diseases for England and Wales. The explanation of this is not apparent unless it be that the child who escapes exposure to tuberculous infection without developing clinical tuberculosis has received some added protection to other infections. Midgley Turner also carried out an investigation to ascertain the condition of 833 contacts of 185 sputum-positive cases of tuberculosis of the lungs during the period extending from January 1st 1927, to August 1929; of these cases one hundred were males and eighty-five were females. The results of the investigation are best shown in the table on page 78, slightly abridged, which has been taken from the author's paper, and which gives the condition of all contacts at the latest report up to August 1929. The age of the contacts is their age at the death of the sputum-positive case, if at this time they were living, or their age at death, if they died before the sputum-positive case.

An analysis of the figures in this table shows that the tuberculosis death-rate per 1,000 contacts was 34·8, the rate for pulmonary tuberculosis being 20·4, and that for non-pulmonary tuberculosis 14·4. The usual high figure of deaths in the under five group from the latter form of the disease will be noted; all the twelve deaths from non-pulmonary tuberculosis occurred in children, of whom ten were under the age of five years. In this connexion it has to be remembered that in young children a primary infection which is rapidly fatal is invariably a general infection, and although the chief clinical feature may be due to disease of some special extra-pulmonary structure, such as the meninges, the lungs are almost certainly also involved.

An exhaustive investigation on Tuberculosis Mortality in Children and the Incidence of Tuberculosis in Children under Fifteen has been carried out by Dorothy Low and W. Lloyd. The communications which describe the results of this investigation are concise and informing, and should be studied by those interested in the subject. It is not permissible to discuss in detail all the enlightening material contained in these papers, but reference must be made to some of the findings which are of special significance. In the investigation an inquiry was made as to the fate of 1,192 children who had been born of parents

Age Group of Contacts	Number of Contacts	Well	Died		Notified Tuberculosis			Suspicious of Tuberculosis
			Pulmonary Tuberculosis	Non-Pulmonary Tuberculosis	P.T. T.B.+	P.T. T.B.—	N.P.T.	
0–5	98	54	—	10	—	1	6	6
5–15	170	132	1	2	—	13	7	15
15–25	194	153	10	—	8	9	2	11
25–35	116	94	4	—	5	4	—	9
35–45	69	59	1	—	5	2	—	2
45+	186	169	1	—	2	3	1	6
All ages	833	661	17	12	20	32	16	49

who attended Brompton Hospital, and who were born after the diagnosis of tuberculosis had been made; the results are summarized as follows:

Death-rate from Tuberculosis in Contact Children in the various Groups under the Age of Five

Group	0–1 year	1–5 years
	per cent	per cent
Mother T.B.+	1·88	0
Father T.B.+	1·77	1·75
Parent T.B.+	1·83	0·91
Parent T.B.—	0·47	0·73
Parent non-tuberculous	0·58	0·79

Some results of special significance are shown in this table. The highest death-rate occurred in infants under one year in contact with mothers with positive sputum, and this is in agreement with the results obtained by other observers, although lower than most of those previously mentioned. The high death-rate in the one to five age-group of children in contact with a positive father compared with nil for a positive mother will be noted. This agrees with the findings of other observers and the experience of clinicians, namely, after the period of infancy the father with positive sputum becomes the greater danger. The authors in their paper draw attention to the fact that all the deaths from meningitis occurred in groups in which a parent had positive sputum, and they state that this is by far the most fatal form of the disease in early childhood.

In their second communication the authors record the results obtained in their investigation as to the ratio of positive tuberculin reactors in a series of children belonging to families of an urban working-class population. They discuss *inter alia* the relative accuracy of the Mantoux and Pirquet tuberculin tests, to which reference is made in a subsequent chapter. In the following table they give the results of their application of the Mantoux test in a series of 1,003 children.

Percentage Reactors in Contact and Non-contact Groups

Age	Contact T.B.+			Contact T.B.—			No contact with Tuberculosis		
	Number of Cases	Number Positive	Per cent Positive	Number of Cases	Number Positive	Per cent Positive	Number of Cases	Number Positive	Per cent Positive
0–5	21	15	71·4	15	3	20·0	103	14	13·6
5–10	87	66	75·9	47	18	38·3	404	126	31·2
10–15	76	58	76·3	33	14	42·4	217	118	54·4
0–15	184	139	75·5	95	35	36·8	724	258	35·6

Two points of special interest arise in connexion with these figures. It will be observed that the percentage of positive reactors at the ages ten to fifteen in the non-contact group is considerably higher than in the corresponding age-group of contacts with sputum-negative patients. This is difficult to explain, but it tends to support the view that there does not exist as an infective agent any ultra-microscopic form of the tubercle bacillus. It will also be noted that the percentage of positive reactors in the under five age-group of non-contacts is only 13·6, whereas in ten to fifteen age-group it is 54·4. The question which inevitably arises from these figures is: how does infection in this age-group take place in the absence of house infection? Is it in the school, in the playground, in the street, or is it through milk? It is impossible to envisage such infection without postulating the existence of some method other than home contact by which the tubercle bacilli may gain entrance to the human body.

D'Arcy Hart gives the following results as to the ratio of positive tuberculin reactors in contacts and non-contacts in sections of the population in this and other countries:

London (Mantoux) home contacts: 37 per cent under the age of two; 70 to 80 per cent in the age-group eight to nine with gradual decline to the age of fourteen; general population: under 10 per cent at the age of two, over 50 per cent at the age of twelve, and 99 per cent at the age of twenty-two. Paris (Mantoux) general population, 29 per cent at the age of two and 80 per cent at the age of eleven. Wealthier class (Pirquet), under 10 per cent at the age of two and 50 per cent in the age-group five to six. Madras (Pirquet), 60 per cent under the age of two, 80 to 90 per cent at the age of twelve, and over 90 per cent at the age of twenty-two. Philadelphia (Mantoux) home contacts: 80 per cent between ages of two and three, 90 per cent just over the age of twelve, and 100 per cent over the age of twenty-two. New York (Mantoux) poorer class: over 20 per cent at the age of two and nearly 80 per cent in the age-group five to six.

GROUP INFECTION. The most intensive form of contact infection is seen in the group infection which from time to time occurs in families, in schools, and in other institutions. The recognized aetiological factors in group infection are close contact and conditions of life which seriously impair resistance

to infection. In family infection, however, inheritance cannot be altogether disregarded as a factor which contributes to impaired resistance. One is compelled to consider the possibility of inherited predisposition when tuberculosis claims as its victims several members of a family in good circumstances living in a large house and experiencing no depletion of food as regards quantity or quality. Or is the explanation to be found in an exaltation of virulence through transmission from one member to another? In considering the epidemiology of family tuberculosis where several members become fatally infected, the existence of aetiological factors common to all have to be discussed. The most important factor is the source of infection to which all are exposed, and it is generally accepted that all are exposed to infection by the same strain of organism. They are also exposed to repeated doses of infection, but not to equal dosage of infection. As regards predisposing factors the only one common to all in such a family is some degree of inherited susceptibility. While admitting that the continued existence of a definite source of infection is the principal and most significant cause of family tuberculosis, the influence of inherited susceptibility as a contributing factor cannot be ruled out in some families.

INFECTION IN FAMILIES. Illustrations of group infection in families are well known to medical men; fortunately, owing to modern methods of observation and treatment this form of infection is now only exceptionally seen. The gifted Brontë family suffered from tuberculosis, a moving description of which has been given by Sir Arthur MacNalty. The family consisted of six children, five girls and one boy, and the two eldest daughters, Maria and Elizabeth, were sent in 1824, at the age of ten and nine years, to Cowan Bridge School in Lancashire, where there was overcrowding in the dormitories, associated with insufficient and unsuitable food. In the following year there was an outbreak of sickness in the school which was called 'low fever', and Maria and Elizabeth Brontë developed pulmonary tuberculosis in the course of this outbreak. Maria Brontë was removed home to Haworth and died on May 6th, and Elizabeth, who was also removed from school, died on June 15th. Charlotte and Emily Brontë, who had also been pupils at Cowan Bridge School, came back to Haworth on June 1st, but did not return to school, as

its damp situation was considered to be unsuitable to their health. The remaining members of the family, Patrick and Anne, became subsequently infected. Patrick, who had given way to intemperate habits, died in 1848, at the age of thirty-one; Emily died three months later in the same year at the age of thirty; and Anne died in May 1849 at the age of twenty-nine. Charlotte, the member of the family who survived longest, and the only one to marry, died at the age of thirty-nine, and the history of her state of health indicates that she suffered from slowly progressive disease with intermittent phases of exacerbation. In these members of the family the assigned cause of death was consumption or phthisis, with the exception of Patrick, in whose case death was attributed to chronic bronchitis and marasmus, which in a young man of his age and with such a history of contact could only mean tuberculous infection. The writer has met with one or two instances of severe family tuberculosis, in all of which the father was the primary source of infection. One family consisted of sixteen children, only one of whom reached adult life, and seven of whom were known to have died from pulmonary tuberculosis. The father of another family of ten had suffered for a long period from cough and some huskiness of voice; he died at the age of fifty-one from pulmonary tuberculosis; the mother remained well throughout. Of nine children, four died of pulmonary tuberculosis, one from tuberculous meningitis, and four had clinical evidence of pulmonary tuberculosis, of whom three had positive sputum. The ages of the pulmonary cases ranged from sixteen to twenty-five.

INFECTION IN INSTITUTIONS. Reference to the tragic history of the Brontë family directs attention to the possibility of epidemic outbreaks of tuberculous infection in schools and other institutions. The collecting of either young or subnormal persons together in institutions where the feeding and the general hygienic standard, especially as regards cleanliness, fresh air, and spacing, are inadequate is liable to give rise to an outbreak of tuberculosis in epidemic form when once infection is introduced.

An outbreak of this character has been reported in a home which provided accommodation for girls from Boards of Guardians. In the outbreak there were forty cases of illness with eleven deaths which were attributed to tuberculous disease. It was

found that there had existed in the home a focus of tuberculous infection for a period of five or six years, with a fatal case three or four years prior to the date of investigation. The type of child admitted to the home was poor and the group could be regarded as subnormal physically, as they came from destitute homes, while their history in a number of cases showed contact with infection before admission. The conditions in the home which encouraged excitation of infection included overcrowding in dormitories, insufficient diet with meagre milk allowance, absence of regular exercise in the open air, interference with hours of sleep, and no suitable arrangements for treatment and segregation. Sir Arthur MacNalty expressed the view in the report, that 'by passage from individual to individual the virulence of the infection was gradually exalted'. This view is supported by the findings of Topley in other fields of investigation. His findings, however, show that to produce exaltation of virulence in a group after infection has been introduced, the admission of susceptibles is necessary. May not this be the true explanation of group infection, namely, infection, close contact, unfavourable conditions, with the intermittent admission of susceptibles, and in family infection, extreme susceptibility, in some instances. The influence of adverse conditions during the War in increasing the incidence of infection in special groups in a mental institution was investigated by F. A. Elkins and the writer. The following table shows the increase in group infection amongst low-grade mental cases during the War years:

Year	Average Number of Patients	Deaths from all Causes	Mortality from Tuberculosis	
			Deaths	Rate per 1,000
1911	2,049	144	38	18·5
1912	2,068	129	41	19·8
1913	2,051	197	59	29·0
1914	2,099	172	42	20·0
1915	2,045	240	70	34·2
1916	2,041	283	102	49·9
1917	1,941	459	141	72·6
1918	1,769	542	208	117·6

The special features of this group were that it included a high proportion of low-grade mental defectives who were subnormal mentally and physically, and that their habits were such as to facilitate the spread of infection. The increasing death-rate during the War years was no doubt related to depleted diet, more especially in regard to fats.

TUBERCULOUS INFECTION IN NURSES. In relation to the possibilities of contact infection, nurses constitute a special group by themselves. In special hospitals and other institutions which deal exclusively with cases of tuberculosis, the nurses when on duty are in continuous contact with patients having positive sputum, but under conditions of hygiene and prophylaxis which should restrict in large measures the risk of severe or massive infection. In general hospitals, although the number of infective cases of tuberculosis is much less, the precautions carried out to prevent infection are less stringent, so that there is greater risk of contracting an infection sufficient to produce clinical tuberculosis in a general hospital than in a tuberculosis hospital or sanatorium. The incidence of tuberculous infection among nurses in general and in tuberculosis hospitals varies according to different observers. Geer, who investigated the health of 934 nurses, part of whose training included the nursing of tuberculous patients, found that 4·5 per cent developed tuberculosis. He has also shown that probationer nurses who on entrance to the same hospital were tuberculin negative, became tuberculin positive within a period of twelve months, and that out of 147 nurses who had been in the hospital for six months or longer only four were found to give a negative reaction. On the other hand, an investigation as to the incidence of reactors in the nursing staff of hospitals which had no accommodation for tuberculous patients showed that only 41·8 gave a positive reaction. Heimbeck of Oslo has investigated the incidence of clinical tuberculosis in a series of hospital nurses from 1924 onwards, the latest beginning in 1935. His findings are briefly as follows: Of 800 persons who had passed the primary infection without disease 30 developed tuberculous disease; of 387 persons who were primarily infected, 118 developed tuberculosis; of 439 persons vaccinated with B.C.G., 33 developed the disease, and of 287 persons who were vaccinated with B.C.G. until they

became tuberculin positive, eight developed evidence of tuberculous disease. The manifestation of tuberculosis observed in all these groups included, in addition to pulmonary infection, pleuritis and erythema nodosum, the total number of the former being 37 and of the latter 57; the number of cases of pulmonary tuberculosis recorded with positive sputum was 17, which is a small number of the total classed as clinically tuberculous.

The risk of the development of clinical manifestation of tuberculosis in the case of contact nurses who are initially tuberculin negative is shown by the figures of Heimbeck in the following table:

	Number	Years observed	Diseased	Dead	Morbidity (annual percentage)
Probationer Nurses:					
Pirquet Positive .	668	1,772	22	0	1·2
Pirquet Negative .	284	687	97	12	34·3
Graduated Nurses:					
Pirquet Positive .	504	2,946	12	0	0·4
Pirquet Positive (initially negative) .	178	1,361	7	1	0·5

It will be observed from the above table that no deaths occurred among those who were initially tuberculin positive, and that of those initially tuberculin negative thirteen died. Heimbeck concludes that the tuberculosis risk attached to nursing depends upon two factors, namely, whether the women who take up nursing are tuberculin positive without having contracted the disease, and, secondly, the extent of the infection to which they are exposed.

The incidence of tuberculosis in sanatorium nurses varies according to different observers. In the Trudeau Sanatorium and in the Pottenger Sanatorium in America no case of pulmonary tuberculosis in the nursing staff has been recorded during periods of forty-five and thirty years respectively. It is also the general experience in this country that the healthy members of the nursing staff of a well-conducted sanatorium seldom develop clinical manifestations of the disease. Mariette has carried out

an intensive investigation at the Glen Lake Sanatorium on the incidence of tuberculosis in sanatorium nurses which casts an informing light on the subject. The investigation was commenced by instituting the policy of the X-ray examination of all nurses at the commencement of employment and yearly thereafter, and subsequently every three months. The results were as follows: Group i, Supervising Nurses: 123 were X-rayed, of whom 14 were not followed; of the remaining 109 evidence of the adult type of tuberculosis was found on the initial X-ray examination in 16·5 per cent. Of the remaining group with a negative X-ray picture, 8·3 per cent subsequently developed active tuberculosis. Group ii, General Duty Nurses: 610 were X-rayed, of whom 209 could not be followed; of the remaining 401 evidence of adult type of tuberculosis was found in 8·9 per cent on initial X-ray examination. Of the remaining group with a negative X-ray picture, 2·4 per cent developed inactive tuberculosis and 4·5 per cent active tuberculosis. Group iii, Student Nurses: 1,851 were X-rayed, of whom 794 were not followed; of the remaining 1,057 evidence of adult tuberculosis was found in 6·4 per cent on initial X-ray examination; of the remaining group with a negative X-ray picture, 2·9 per cent developed inactive tuberculosis and 2·1 active tuberculosis. Taking the groups together it was found that in the X-ray negative group 3·1 per cent developed active tuberculosis and 2·6 latent tuberculosis. Edwards states that at the Cheshire Joint Sanatorium all new members of the staff are Mantoux-tested and radiographed and he found that out of 54 tuberculin-positive nurses, one developed tuberculosis in six months, while out of 11 tuberculin-negative nurses, 2 became tuberculous. On the other hand no case of tuberculosis developed in 43 domestics of whom 40 were tuberculin positive and 3 were tuberculin negative.

All investigators on this subject, including Mariette, Heimbeck, and Edwards, agree that tuberculin-negative nurses run a greater risk of developing clinical tuberculosis than tuberculin-positive nurses, and this is in accord with accepted views regarding the protective influence of a primary non-clinical infection. The general trend of opinion in this country is that the general hospital nurse is more liable to develop clinical tuberculosis than the sanatorium nurse, and if this view were supported

by statistical evidence, the explanation would be that not only is the sanatorium nurse living under healthier conditions, but, provided a high standard of prophylaxis in the sanatorium is maintained, she is more likely to be infected with small repeated doses over a prolonged period, whereas the hospital nurse is exposed to sporadic infection with more massive doses. In the former case specific protection is more likely to be secured, while in the latter clinical infection is the greater risk.

Chapter Four

HOUSING AND TUBERCULOSIS

IN the preceding chapter reference has been made to unhealthy home conditions as constituting a factor which predisposes to the development of tuberculosis, and it is necessary to examine more closely to what extent such conditions are directly or indirectly related to a high incidence of infection.

The home has come to be regarded as the 'nest' where primary infection most frequently occurs in the case of mothers and young children who spend the greater part of twenty-four hours within its confines, and the conditions of the home and of life within the home therefore stand in definite relationship to the extent to which infection takes place and to the velocity with which it occurs.

DENSITY OF POPULATION. The death-rate from tuberculosis is found to be highest in densely populated urban districts where families live in close proximity to each other and where no attempt is made to separate domiciliary existence from industrial life. This is proved by statistical evidence obtained from the *Registrar-General's Statistical Review* for 1936. The infant mortality from tuberculosis provides a delicate index of the incidence of gross tuberculous infection in the home. For the purpose of comparative statistical review England and Wales have been divided into six geographical regions which, in regard to their density of population, vary within considerable limits, the most densely populated areas being found in the north of England. The infant mortality from tuberculosis in these six regions is shown in the table on page 90.

It will be observed from reference to this table that the highest infant mortality from tuberculosis occurred in two northern regions, No. I, which includes the counties of Durham and Northumberland and No. III, which includes the West Riding of Yorkshire and the county borough of York. The lowest infant mortality from tuberculosis occurred in the South-eastern region outside Greater London and in the No. II district of Wales, which includes nine counties in that country; the four

remaining counties, Brecknockshire, Carmarthenshire, Glamorganshire, and Monmouthshire constituting the No. I region of Wales. These figures indicate a correlation between density of population and the incidence of tuberculosis in infants, but some allowance must be made for the extent to which the death-rates may be influenced by bovine infection.

Geographical Region	Infant Mortality from Tuberculosis	Geographical Region	Infant Mortality from Tuberculosis
South-east . .	0·51	Midland	0·58
Greater London .	0·59	Midland I	0·64
Remainder of South-east .	0·39	Midland II	0·47
North . .	0·72	East . .	0·52
North I . .	0·75	South-west .	0·54
North II . .	0·66	Wales .	0·47
North III . .	0·76	Wales I .	0·53
North IV . .	0·69	Wales II .	0·30

In the past, encouragement has been given to the density of population by the cost of building sites, structural economy, and the necessity of having the homes of the employed in close proximity to the place of employment. It was for these reasons that houses were constructed in back-to-back rows separated by narrow courts, or were built in closely packed tenements or flats. Houses which were constructed on these lines usually provided a minimum amount of accommodation, resulting in overcrowding, which is one of the recognized determining causes of tuberculosis.

The high incidence of tuberculosis in back-to-back houses, which are becoming a housing feature of the past, has been proved by statistical evidence. Tatham pointed out years ago that in the districts of Salford, where all the houses were of the back-to-back type, the death-rate from pulmonary tuberculosis was 5·2 per thousand, whereas in districts where no back-to-back houses existed, the death-rate was 2·8 per thousand. In Liverpool the death-rate from pulmonary tuberculosis for three years in

certain insanitary areas was 4 per thousand. These insanitary areas contained narrow courts with tall, narrow, back-to-back houses consisting of a living-room on the ground floor with one bedroom on the first and second floors, which were reached by a narrow staircase. After these blocks of back-to-back houses had been demolished and new blocks with through ventilation and open spaces had been erected, the average death-rate for three years fell to 1·9 per thousand. The following figures also emphasize the difference between the death-rate from respiratory tuberculosis in houses with through ventilation and that in back-to-back houses. Taking one hundred as the death-rate in houses with through ventilation, the death-rate was found to vary from one hundred in such houses, including those with side ventilation, to one hundred and eleven, one hundred and twenty-six, and one hundred and sixty-seven in back-to-back houses. The erection of back-to-back houses is now prohibited by section 22 of the Housing Act, 1936.

The incidence of tuberculosis is also higher in tenements than in separate dwellings as is well known to every medical practitioner who has practised in a large urban district. Bradbury, in his Tyneside inquiry, found that in Jarrow, which had a much higher incidence of tuberculosis than Blaydon, the proportion of tenements was very much higher, as is shown by the following figures.

	Death-rate from Tuberculosis 1919–1930	Percentage of Flats and Tenements
Jarrow	2·26	75
Blaydon	2·06	23

Certain features of some of these tenements which are of significance as contributing to a higher incidence of tuberculosis, are referred to in the Report. A type common in Jarrow consisted of blocks with one-room dwellings on the ground floor and two-room dwellings on the first floor, so constructed as to be practically back-to-back dwellings when the outside door was closed. The size of the rooms, especially that of the bedroom, in

the two-room dwellings, made overcrowding in its worst form inevitable, so that in this type of tenement there existed, apart from other serious sanitary defects, the two cardinal domiciliary factors which influence the prevalence of tuberculosis, namely, overcrowded one- and two-room dwellings aggregated together so as to be virtually of the back-to-back type.

OVERCROWDING. It has long been recognized that domiciliary overcrowding is a definite factor in the causation of tuberculosis and other forms of respiratory disease. The size of the house, the ratio of persons per sleeping-room, children over ten years of age being classed as adults, and the cubic capacity available per person, stand in close relationship to the prevalence of the disease.

The extensive surveys carried out by Local Authorities under the Housing Act, 1935, now repealed by the Housing Act, 1936, have yielded accurate information regarding the extent to which overcrowding exists in the country, and the results obtained are embodied in a valuable report issued by the Ministry of Health. The most overcrowded districts in the country are the metropolitan boroughs of Shoreditch and Stepney, the counties of Durham and Northumberland, and the city of Sunderland. The death-rates per million from respiratory tuberculosis in these districts in 1936 were as follows: Shoreditch 585, Stepney 693, Sunderland 782, county of Durham 606, and county of Northumberland 551.

In 1898 Shirley Murphy pointed out that the average annual death-rate from pulmonary tuberculosis per 100,000 of population in London for the years 1884–98 rose *pro rata* with the proportion of the population living more than two in a room. The death-rate varied from 111 in districts where such proportion was less than 10 per cent to 259 in districts where the proportion was over 35 per cent. In Edinburgh for the year 1911 it was found that while 1 per 1,000 of the population had pulmonary tuberculosis in houses of four or more compartments; 2·7 were affected in houses of three rooms; 4·8 in houses of two rooms, and 7·4 in houses of one room. During the years 1910–12 the death-rate from tuberculosis of the lungs per 100,000 was 56 in houses of four rooms and upwards, 111 in houses of three rooms, 146 in houses of two rooms, and 225 in houses of one apartment. In

Greenock the death-rate per 100,000 for 1913 was 87 in houses of four rooms and upwards, 106 in three-roomed houses, 179 in two-roomed houses, and 222 in one-roomed dwellings. In Glasgow the corresponding death-rates per 100,000 were 70, 120, 180, and 240. In Newcastle figures submitted by Hurrell show that in 1926 the death-rate from pulmonary tuberculosis in overcrowded parts of the city was 1·3 per 1,000, 0·9 in areas which were moderately crowded, and 0·6 in those parts of the city where no overcrowding existed. Hurrell further points out that overcrowding exercises an influence on the type of the disease which under such conditions is more frequently characterized by caseating lesions than by fibrosis. This he attributes to lack of resistance, which is no doubt true, but the influence of exaltation of virulence by subculture of the strain of organism has also to be considered as a possible factor.

Bradbury in his investigation found a similar correlation between the ratio, of persons per room and the percentage of tuberculous families. In Jarrow, where the ratio of persons was less than one person per room, the percentage of tuberculous families was 27·1, on the other hand when the figure rose to three or more persons per room the percentage of tuberculous families rose to 54·5. The corresponding percentage of tuberculous families for Blaydon were 13·6 and 42·9 respectively. Bradbury draws attention to one conclusion which emerges from his figures, namely, that the incidence of tuberculosis is higher among families overcrowded in small rooms than in families overcrowded in large rooms.

In the Report of the Ministry of Health on Tuberculosis in Wales special reference is made to overcrowding and insanitary housing conditions as important contributory causes of the excessive mortality in that country, especially in the 15–25 female age-group. Attention is drawn in the Report to the Celtic type of house which consists of two rooms with a triangular loft above for further sleeping accommodation which has little or no ventilation, and which makes overcrowding under the worst possible conditions inevitable.

The aetiological relationship between overcrowding and tuberculosis may be accepted as being twofold in character. If a focus of infection be present, the close personal contact which is

inseparable from overcrowding obviously facilitates droplet infection and, further, must facilitate infection with massive doses. Moreover, in a small, overcrowded room cleanliness is more difficult to maintain, while dust is in a constant state of disturbance owing to the movements of a relatively large number of persons within a small compass, so that there exists the added risk of dust infection. The adverse influence of overcrowding on the general health and on general resistance to disease and infection has also to be considered. While it is difficult to compute accurately the extent and character of the impaired resistance which is induced by living under conditions of overcrowding, there is definite evidence to show that the general health suffers and consequently that the individual is more liable to develop clinical manifestations of infection.

The effect of overcrowding on the general health may be envisaged to some extent by the conditions to which it gives rise, namely, still, moist air, raised temperature, organic pollution, and increase in bacterial flora. The physical properties of air in relation to impaired health have been investigated by Sir Leonard Hill, who states that physiological research has proved conclusively that it is not the chemical impurity of close air but its heat and moisture which make for discomfort and impaired health, and that it is the lack of windage which explains the association of density of population with high morbidity and mortality. In excessive overcrowding such as has occasionally occurred with tragic results, the after-effects in those who have escaped, included interference with the balance of nutrition. It is generally known that the breathing of vitiated air for any extended period of time gives rise to a feeling of lassitude, headache, accelerated respiration, and slowing of the heart, and if associated with overcrowded conditions in the home it is likely to result in anaemia, loss of appetite, and impaired nutrition, conditions which are known to decrease resistance to tuberculous infection. If the breathing of vitiated air in the home adversely affects the standard of nutrition, the correlation between overcrowding and a high incidence of tuberculosis receives further support.

The extent to which organic pollution may be associated aetiologically with tuberculosis is at present unknown, and there exists no reliable data in support of the view that such association

exists, although the whole history of the disease in man and in the lower animals indicates the probability of some connexion. In the overcrowded home where cleanliness is neglected, many sources of organic pollution are to be found. Expired air is not however, accepted as one of these sources, as Haldane, Lorrain Smith, and other observers have shown experimentally that expired air contains no organic bodies of a toxic character, although traces of ammonia are eliminated, the amount of which is increased when the air is expired by an individual with septic teeth.

The extent to which bacteria exist and survive in the home depends upon a variety of conditions, such as moisture, absence of direct sunlight, absence of cleanliness, and the number of occupants. The maximum figure as regards actual number of bacteria is reached in dark, moist, unclean, and overcrowded rooms. It has been shown that in one-roomed dwellings an average of sixty organisms per litre has been obtained from the air, in two-roomed dwellings forty-six, and in four or more roomed dwellings only nine organisms per litre have been found. It has been suggested that a limit of twenty organisms per litre should be accepted as a pure air standard for dwelling-houses and schools.

The duties of a local authority in regard to the abatement of overcrowding are laid down in section 57 of the Housing Act, 1936. Section 58 of the Act specifies overcrowding in a dwelling-house as occurring when the number of persons sleeping in the house either (*a*) is such that any two persons of opposite sex, ten years old or more and not living together as husband and wife must sleep in the same room or (*b*) is in excess of the permitted number of persons as defined in the Fifth Schedule to the Act. In determining the number of persons in relation to overcrowding the Act provides that no account need be taken of a child under one year of age and that a child who has attained one year but is under ten years of age is to be regarded as one-half of a unit.

The permitted number of persons as referred to in the Fifth Schedule to the Housing Act, 1936, is shown in the table on page 96.

Section 57 of the Act imposes upon every Local Authority the duty to carry out inspection with a view to ascertaining what dwelling-houses are overcrowded in their area and to submit reports and proposals regarding the action to be taken to abate overcrowding. Under section 59 it is an offence for the occupier or the landlord of a dwelling-house to permit it to be overcrowded after the appointed day. The Local Authority

however, has power to authorize the temporary use of a house by persons in excess of the permitted number. Section 67 of the Act provides that the duties of the medical officers of health of boroughs and urban and rural districts shall include the duty of submitting annually to the Minister of Health particulars in regard to overcrowding in dwelling-houses and more especially regarding any cases in respect of which the Local Authority has taken action to abate overcrowded houses which again have become overcrowded. The Public Health Act, 1936, gives increased powers to local authorities to deal with unhealthy domiciliary conditions. Under section 92 the definition of a statutory nuisance includes any premises in such a state as to be prejudicial to health or a nuisance. The measures to be adopted to secure a satisfactory domiciliary standard and to prevent the spread of infectious diseases in canal boats, vessels lying in inland or coastal waters, and in tents, vans, or other moveable dwellings are laid down in sections 249 to 258 and in sections 267 to 269 of the Act.

TABLE I		TABLE II	
Number of Rooms	Number of Persons	Floor Area of Rooms	Number of Persons
One room	Two	110 sq. ft.+	Two
Two rooms	Three	90 sq. ft.,+ but under 110 sq. ft.	One and one-half
Three rooms	Five	70 sq. ft.+, but under 90 sq. ft.	One
Four rooms	Seven and one-half	50 sq. ft.+, but under 70 sq. ft.	One-half
Five rooms	Ten plus two for each room over five	Under 50 sq. ft.	Nil

ENVIRONMENTAL CONDITIONS. The sanitary standard of a dwelling-house depends not only upon its design, structure, and internal arrangements, but also upon the character of its surroundings. When these are of such a character as to promote dampness of subsoil, smoke and fog, and to restrict the

free circulation of air and the free admission of sunlight the health of the inmates tends to become impaired.

Excessive dampness has been regarded as indirectly associated with tuberculosis. Buchanan, from an investigation made years ago, came to the conclusion that there existed some relationship between dampness of subsoil and tuberculosis. In small, damp houses, especially in country districts, the air tends to remain still and moist, a condition which is not conducive to a high standard of health. Gordon held the view that the incidence of tuberculosis was highest in districts exposed to rain-bearing winds, and he published the results of a careful series of investigations on the subject. This view is supported by evidence submitted by Brownlee. It is known from clinical observation that high rain-bearing winds adversely affect the condition of persons suffering from pulmonary tuberculosis, and tend to increase cough and expectoration. Gordon's contention is also supported by Sir Leonard Rogers who from an extensive study of the prevalence of tuberculosis in India concludes that a considerable rainfall accompanied by strong rain-bearing winds carrying a high degree of absolute humidity to the affected area favours a high incidence of tuberculosis. On the other hand, Morland, while agreeing as to the existence of evidence that warm, damp climates are associated with a relatively high tuberculosis death-rate, considers that climate has much less influence on tuberculosis mortality than racial immunity and social conditions.

The extent to which sunlight and external air gain access to a dwelling-house in urban districts depends largely upon environmental conditions. The aggregation of houses in congested areas and the proximity of dwelling-houses to buildings of much greater height interfere with the circulation of air and the transmission of direct sunlight, while smoke and fog cut out partially or completely the rays of the sun.

To avoid the stagnation of air which occurs in congested areas it is necessary to have wide streets and to eliminate narrow courts and cul-de-sacs. Domestic dwellings must have open spaces in front and at the rear. The amount of direct sunlight which gains entrance to dwellings depends upon the width of the street and the height of the neighbouring buildings. Where the height of the building opposite exceeds the width of the street the amount

of direct sunlight which enters the rooms of domestic buildings is reduced to a very small fraction in the case of the ground floor, and where the street or court is very narrow direct sunlight will be excluded from all rooms below the second floor.

The sun's rays are further cut off by smoke and fog in large industrial districts. Sunshine is composed of three varieties of rays—heat, light, and ultra-violet; these are all interfered with by smoke and fog. In a smoky atmosphere the sulphur compounds are increased, the heat rays are diminished, and the cold humidity of the air is increased by delayed evaporation. Fog is produced by the condensation of moisture which fixes the carbon and dust particles in the atmosphere and gives rise to a dark canopy of varying depth; a fog which lasts for two or three days, associated with a low temperature, is especially trying.

Fog and smoke readily interfere with the transmission of ultra-violet rays, which are the shortest wave-lengths. The mortality from respiratory diseases, including pulmonary tuberculosis in infants under the age of twelve months, is higher in urban districts which have a smoky and dusty atmosphere. The value of the sun's rays in conserving health is well known. The ultra-violet rays and the infra-red or heat rays stimulate the red blood corpuscles to increased functional activity and raise the resistance of the body to disease. In this connexion it is interesting to consider the inhibitory action exercised by haemoglobin, which contains iron. Cathcart states that a trace of copper is necessary to normal haemoglobin. Davies and Loewenstein, have found that haemoglobin and excess of iron inhibit the growth of the tubercle bacillus. It is not difficult, therefore, to envisage that the destruction of any tubercle bacilli which gain entrance to the blood-stream, provided dosage is not excessive, depends upon the condition of the blood and its constituent haemoglobin. Ultra-violet rays are of special importance in relation to the prevention and treatment of tuberculosis. By direct action on the human body they ionize the ergosterol in the skin and convert it into vitamin D, thus providing an important source of supply of this vitamin. The extent to which vitamin D is supplied from this source depends upon the amount of ergosterol or skin fat which is available and the facility with which the ultra-violet rays reach the skin. These rays are also destructive to micro-organisms, so

that when transmitted directly into the dwelling-house they are beneficial in a twofold yet distinctly separate capacity.

A COMMON FACTOR. A study of adverse housing conditions in relation to tuberculosis points to a common factor which appears to be of aetiological significance. A common result of overcrowding, stagnant air, and the cutting off of ultra-violet rays is impairment of the normal balance of nutrition which includes a subnormal resistive capacity of the blood, and where this unbalance is further accentuated by insufficient or unsuitable food the position is reached when the capacity to resist the clinical development of tuberculosis becomes seriously impaired. All the indications point to one conclusion, that apart from the influence of specific protection on the one hand, or the possibility of an extreme natural susceptibility on the other, the capacity to resist tuberculosis is governed by an adequate intake of essential food constituents and by healthy home conditions and surroundings, both of which determine the standard of nutrition.

HOUSING CONSTRUCTION. The elimination of overcrowding and of the house unfit for human habitation necessitates the provision of new housing accommodation. Section 71 of the Housing Act, 1936, places upon Local Authorities the duty of reviewing periodically the housing conditions in their areas and to prepare and to submit proposals to the Ministry of Health for the provision of new houses. The method of such provision is laid down in section 72 of the Act as follows: (*a*) by the erection of houses on any land acquired or appropriated by the Local Authority, (*b*) by the conversion of any buildings into houses for the working-classes, (*c*) by acquiring houses suitable for the purpose, and (*d*) by altering, enlarging, repairing, or improving any houses or buildings which have been acquired by the Local Authority.

The powers of Local Authorities under the 1936 Act in regard to the provision of housing accommodation are wide and comprehensive, and if applied with true appreciation of the value to health of good construction, planning, and siting, and with foresight in regard to future developments and requirements, they should be instrumental in securing a higher standard of health and a further decline in the incidence of tuberculosis.

The essential requirements of a healthy house are dryness,

adequate ventilation, and natural lighting. The foundations of the house should consist of a concrete basis which will exclude dampness and ground air. Dampness of the walls must be prevented by reliable damp-proof courses and by covering the walls above the ground-level with suitable material or by the adoption of other means to make them impervious to driving rain. Other causes of dampness due to structural defects must be eliminated. Windows must be made of a size sufficient to provide adequate natural lighting and should be so constructed as to permit of them being readily opened so that the principle of the open window may be easily applied in practice. A house which is well illuminated with sunlight makes for cleanliness and health.

Each room in a house should be provided with at least one window which communicates directly with the open air. In a bedroom where there is no fireplace some additional means of ventilation must be provided. The total window surface should be not less than one-tenth of the floor area of a room, and there should be no added obstruction to the transmission of sun's rays through the glass.

The size of a dwelling-house and the area of the rooms in relation to health depend on the number and age of the occupants; space, light, and moving air are essential to the health of young adults and children.

REPAIR AND DEMOLITION. Apart from new construction on sound lines, improvement in the standard of housing calls for sustained investigation as to the need for repair and demolition. By judicious repair and reconditioning with due regard to the access of air and light, existing houses which are considered unfit for '*healthy*' human habitation can be sufficiently improved to conform to what is regarded as necessary to constitute a healthy house. Section 9 of the Housing Act, 1936, empowers Local Authorities to require owners of houses which are represented as being unfit for human habitation to execute such necessary repairs as are specified in the notices at reasonable expense. Section 88 of the Act places upon County Councils the duty of giving constant regard to the housing conditions of persons of the working-classes in rural districts, and of furnishing information regarding such conditions at intervals of not less than

one year. Section 89 of the Act empowers County Councils to assist rural district councils in the provision of housing accommodation. In rural districts assistance towards the improvement of existing houses is available under 'The Housing (Rural Workers) Acts, 1926 and 1938', which empower Local Authorities to give financial assistance by way of grant or loan to owners of houses to enable them to carry out the structural work which is necessary to secure reconditioning and improvement. The aim of the Acts is to promote the provision of improved housing accommodation for agricultural workers and this is further facilitated by the Housing (Financial Provisions) Act 1938.

In many rural districts there exist cottages and small isolated houses which are far below the necessary standard of fitness for healthy habitation. Improvement in the housing conditions in rural districts so as to retain and to attract rural population is of primary importance in relation to the prevention of tuberculosis, while it is also an essential factor in relation to food production and in regard to safety and the preservation of life in time of war. An essential part of any national fitness campaign should be to persuade the people to live in the country and to promote rural employment and industries.

When a dwelling-house is certified as unfit for human habitation and cannot be reconstructed at a reasonable cost so as to be rendered fit, the Local Authority has power under section 11 of the Housing Act, 1936, to make an order for the demolition of the house, which must be carried out within a specified period of time. Section 12 of the Act empowers the Local Authority to make a closing order prohibiting the use of any part of a building or of a room, such as an underground room, which is unfit for human habitation. By such means the perpetuation of living under housing conditions which are seriously prejudicial to health can be prevented, and although it is impossible to secure immediate improvement in all respects the cumulative effect which will inevitably follow the application of powers under recent legislation on housing will secure a much improved standard which will aid materially in further reducing the incidence of tuberculosis.

Further important powers are given to Local Authorities by sections 25–33 of the Act which deal with clearance areas. An area is defined

as a clearance area when the Local Authority passes a resolution to that effect after being satisfied as regards the area (*a*) that the houses in that area are by reason of disrepair or sanitary defects unfit for human habitation, or are by reason of their bad arrangement, or the narrowness or bad arrangement of the streets, dangerous or injurious to the health of the inhabitants of the area, and that the other buildings, if any, in the area are for a like reason dangerous or injurious to the health of the said inhabitants; and (*b*) that the most satisfactory method of dealing with the conditions in the area is the demolition of all the buildings in the area. The sections of the Act which deal with clearance areas are of special value in relation to the prevention of tuberculosis as they provide for the elimination of those congested overcrowded areas in which the dwelling-houses are cut off from adequate moving air and sunlight and in which the incidence of the disease is high.

Important provisions of the Housing Act, 1936, relate the making of bye-laws. Section 6 of the Act provides that a Local Authority may, and if required by the Minister of Health, shall, make and enforce bye-laws with respect to houses occupied or of a type suitable to be occupied by persons of the working-classes. These bye-laws relate *inter alia* to the inspection of houses, the number of persons who may occupy a house, the promotion of cleanliness and ventilation, the adequate lighting of rooms, and the cleanliness and redecoration of the premises at stated times. Section 84 empowers a Local Authority to make bye-laws for the management, use and regulation of houses provided by them.

The Housing Act, 1936, consolidates the Housing Acts, 1925 to 1935, and if its provisions are carried out with due regard to the influence which good housing conditions exercise on the standard of public health, and if there is uniformity of aim in regard to bye-laws and to the manner with which they are complied, the Act will give an added and sustained impetus to the elimination of those domiciliary conditions which pave the way for tuberculosis.

TOWN-PLANNING. The importance of town-planning in relation to the health and the development of urban districts has come to be recognized; it has been the subject of various enactments dating from 1909, and the various Acts which have been passed since that date have been consolidated in the Town and Country Planning Act, 1932. The aim of town-planning schemes is to control building development so as to conserve urban amenities and to secure environmental conditions which

will conduce to health and the enjoyment of life. The particulars of a town-planning scheme as laid down in the Ministry of Health's Circular 1305 include the defining of the type and use of buildings to be permitted in different parts of the district, the lay-out as regards new streets, roads, and building lines, the widening of existing streets, the density of buildings, i.e. the number of dwelling-houses per acre and the space around such buildings, the size, height, and design of buildings, the prohibition or restriction of buildings on certain areas, and the reservation of areas for open spaces, allotments, or for other special purposes. (See also Model Clauses 1938.)

The practical application of these broad principles will result in the production of urban areas which do not repeat the indiscriminate siting and congested errors of the past. It will provide for the free circulation of air and the access of sunlight. It will in fact secure in existing urban districts an advance towards the conception of the garden city. It is the bringing of the rural conception of life as regards moving air, sunlight, space, and other amenities into urban existence which will exercise a definite influence in raising the standard of the national health in these districts and in diminishing still further the incidence of tuberculosis. Considerable progress has been made since the passing of the Act of 1932 in schemes of town- and country-planning, and the very extensive area in England and Wales which is now under planning control is an indication of what has been done in this direction.

GARDEN CITIES. The garden city movement in this country owes its inception to the fertile mind and enlightened views of the late Sir Ebenezer Howard. A garden city has been defined as 'a town designed for healthy living and industry; of a size that makes possible a full measure of social life, but not larger, surrounded by a rural belt; the whole of the land being in public ownership or held in trust for the community'. The principle of the movement is to combine as far as is practicable the benefits and amenities of rural life with the social and industrial advantages of urban existence so devised as to promote the healthiest possible conditions of life. The first concrete example of the application of this great principle in this country is to be found in the Garden City of Letchworth. A characteristic and

advantageous feature of the Garden City is its lay-out, which follows a fixed principle. It provides that residential and industrial districts shall be kept distinct and separate, and that the environmental amenities of the whole district shall be conserved by adequate spacing, zoning, and a surrounding agricultural belt, while every attention is paid to the width of streets, grass verges, siting, and general design so that the conditions as regards sunshine and circulation of air approximate as near as is possible to those obtaining in healthy rural districts.

An accurate index of the health standard of a community is to be found in the infant mortality and in the death-rate from tuberculosis of the respiratory system. In the table opposite these rates over a period of eight years for the Garden City of Letchworth are compared with the corresponding rates for the county of Hertford and England and Wales.

HOUSING TUBERCULOUS PATIENTS. The provision of houses for persons suffering from tuberculosis with a view to conserve the benefits obtained by treatment and to minimize the risk of infection is one which has received attention. The individual who suffers from chronic tuberculosis and whose working capacity has been restored by a term of treatment does not possess any great fund of reserve against relapse. A return to conditions of life which are not compatible with a normal standard of health is almost certain sooner or later to break down the reserve of resistance which exists and lead to relapse. This is one of the most difficult problems in regard to the treatment and prevention of tuberculosis which remains to be solved. The problem does not alone affect the individual suffering from the disease; it relates also to the members of his family who are in contact with a source of infection should the disease be or become of the open type.

Some authorities have endeavoured to meet this problem by providing specially designed houses for tuberculous families, but to provide certain houses or groups of houses with special structural features for families with members suffering from tuberculosis has not for obvious reasons proved a practical policy. If the type of house provided in housing schemes be of a satisfactory standard as regards dryness, size of room, window surface, cross-ventilation, and bedroom accommodation, such a house in the

		1930	1931	1932	1933	1934	1935	1936	1937
Infant Mortality	Letchworth	30	41	62	30	20	17	32	27
	County	42	46	50	42	37	35	37	37
	England and Wales . . .	60	66	65	64	59	57	59	58
Death-rate Tuberculosis of Respiratory System	Letchworth	0·4	0·3	0·4	0·4	0·4	0·3	0·3	0·4
	County	0·5	0·4	0·5	0·5	0·4	0·4	0·4	0·3
	England and Wales . . .	0·7	0·7	0·6	0·6	0·6	0·6	0·5	0·5

absence of overcrowding and unhealthy environmental conditions is quite compatible with the maintenance of resistance, provided always that the intake of suitable food is adequate. The Local Authority can do much in a general way to assist in meeting the difficulty. By taking a comprehensive view regarding the relation of good housing conditions to the public health, it is possible to secure that the design and type of house in all housing schemes should conform to a standard that will not only maintain the health and resistance of healthy occupants, but will assist in maintaining the resistance of the individual in whom the disease has become arrested. By giving preference to the transfer of families with a tuberculous member from an unsuitable house to a more healthy council house real assistance can also be given.

Chapter Five

MILK SUPPLY AND TUBERCULOSIS

ONE of the principal sources of tuberculous infection in the human subject is milk containing bovine tubercle bacilli. While milk is the chief medium through which bovine infection occurs, it has been shown that aerogenous infection among those in contact with cattle also takes place, while cutaneous infection through inoculation is by no means rare. The clinical manifestations of infection to which the bovine type of tubercle bacilli gives rise necessarily vary according to the structure or organ primarily invaded, the mass of the dosage, and the resistance of the individual. More detailed reference to the various types of bovine infection in the human subject has been given in a previous chapter.

As is the case in the human subject, the bovine animal may be infected without showing any obvious clinical manifestations of the disease or without giving rise to any suspicion that it is expelling tubercle bacilli. On the other hand, the existence of gross lesions may be obvious, as in well-marked disease of the udder. The period of time which elapses between the onset of infection and its detection may be a prolonged one, and as during the greater part of this period tubercle bacilli may be expelled in the milk, from the lungs, or in the faeces, there is serious risk of the transmission of infection to the human subject.

That tubercle bacilli may be present in the milk without clinical evidence of udder disease has been proved by various observers, including Sir William Savage, Ishiwara, Rabinowitsch, De Jong, and others. Jordan found that of 636 reactors with no clinical tuberculosis, in 1·4 per cent a positive result was obtained by the injection of milk into guinea-pigs, when both the intra-peritoneal and sub-cutaneous methods were employed.

Tubercle bacilli may also be expelled in the faeces of infected but apparently healthy animals, the origin of the bacilli being usually swallowed sputum from an open pulmonary lesion. Various observers have confirmed the finding of tubercle bacilli

in the excreta of apparently healthy cows. Stenhouse Williams and Hoy obtained a positive result in 1·9 per cent of 256 tests. Peters and Emerson found out of forty-one animals examined that in 7·3 per cent tubercle bacilli were being passed in the faeces, and Reichel and Deubler obtained a similar result in 10 per cent of nineteen animals examined.

The possibility of milk becoming infected with tubercle bacilli through the medium of dust or excreta must also be considered, especially when contamination with coliform organisms exists and the presence of tubercle bacilli is demonstrated by the biological test. The following result of a sample of milk suggests this possibility:

> Sample W. R. H.
> No. of bacteria per 1 c.c., 265,000.
> B. Coli present in 1/100th, 1/1000th, and 1/10,000th c.c.
> Centrifugalized deposit shows some long chains of streptococci; no tubercle bacilli detected. Biological test: guinea-pig inoculated with centrifugalized deposit showed typical tuberculous lesions on post-mortem examination.

The source of origin of coliform bacilli in milk and foodstuffs has been conclusively proved by the investigations of Wilson and others. From a research based on the investigation of the cultural and bio-chemical features of 648 strains of bacilli of the coliform group the authors confirmed the view that the organisms of this group found in milk and in the foodstuffs of cows are of excremental origin.

The association of a somewhat gross coliform contamination of milk with infection with tubercle bacilli in small numbers should direct attention to the possible existence of an animal or animals with pulmonary lesions from which bacilli are being expelled from the lungs or in the faeces. Reference may be made here to the value of combining the methylene blue test with a plate count and the coliform test. A positive methylene blue reaction has in the writer's experience been associated with a high plate count and a negative coliform test, or a low plate count (14,000) with the presence of coliform organisms in all three tubes. These results shed light on the probable reason for the methylene blue test being positive; in the former defective cooling and unclean vessels and in the latter unclean animals or cowshed.

INCIDENCE OF INFECTION. Tuberculosis is a prevalent infection in dairy herds, and as it is essentially chronic in character it may exist in any stage from early development to advanced manifestations of the disease. The extent of the incidence of infection and disease is shown by the ratio of reactors, the post-mortem findings in abbatoirs, the percentage ratio of milk examinations which gives positive findings, and the results obtained from clinical examination by veterinary surgeons.

The ratio of positive reactors among cattle increases with the age of the animal. In young animals the percentage is relatively low, but in old animals a high percentage will be found to react. According to Bang's figures for Denmark, which are based on the examination of 40,624 animals, the percentage of reactors for animals of different ages is as follows: under six months, 12·1 per cent; six to eighteen months, 27·5 per cent; two years, 38·6 per cent; and over five years, 48 per cent. As regards the reactor percentage for all ages, the following figures are supplied by De Vine for herds round Birmingham for the years 1907–27, representing a total of 2,136 animals. The highest percentage obtained was 67·6 by the intra-dermal test in a group of 169 animals, and the lowest percentage was 4·9 in a herd of 41 animals. The average percentage of reactors for the whole series was 40·4.

The percentage of animals reacting to tuberculin varies in different countries and in different parts of country. In Great Britain it is estimated that on an average 40 per cent of cows in dairy herds react to the tuberculin test. Earlier investigations have shown a considerable variation in the percentage in different parts of the country. The results of a survey during 1897–9 showed that in Cornwall, Devon, Dorset, and Somerset 7 per cent of cows reacted to the sub-cutaneous test, whereas in Sussex and Hampshire the proportion was 50 per cent.

The results of investigations with the tuberculin test abroad also show variations. In the Netherlands Charlotte Ruys gives the results obtained in two series of animals, one of which comprised 11,000 animals, in which the percentage of positive reactors was 40·8; in the other series the percentage was 21. In Sweden the percentage of reactors is stated to be 4·7 per cent in the north and 30–40 per cent in the south. In Norway the incidence of bovine infection has always been low. The first investigation

in 1895 showed 5 per cent of reactors, and this figure as a result of active and intelligent measures has been reduced to 0·18 per cent. In the United States of America where the measures adopted include the elimination of positive reactors, a very low incidence of infection, as shown by the following figures, is found:

Year	Animals Tested	Percentage Reacting
1919	329,878	4·1
1929	11,683,720	1·8
1936	22,918,038	0·7

The post-mortem evidence of tuberculous infection in cows shows a striking agreement with the positive results obtained by the tuberculin tests; the figures for both being in the neighbourhood of 40 per cent. From a survey of all available figures it has been shown that of a total series of 55,318 cows slaughtered 39·5 per cent were found to present microscopic evidence of tuberculosis. In 1929 the figures for the Metropolitan Cattle Market, Islington, showed that 51 per cent of the cows slaughtered were found to be tuberculous. As is the case with tuberculin tests, the older the animal the more frequent is the evidence of tuberculous disease found on post-mortem examination. Cobbett, in a series of 379 animals of different ages based on Delepine's analysis, gives the following results:

Age in years	0–1	1–2	2–3	3–5	5–9	9–13	Total
Percentage Tuberculous	3·4	13·2	24·1	23·5	48·9	76·0	30·5

The sharp rise after the ages of one and five years, and the high percentage of tuberculous animals after the age of nine will be noted.

The high incidence of infection in cows, especially old cows, compared with that in other bovines is significant and sheds light on certain aetiological factors responsible for the disease.

Figures given from various sources show that whereas the ratio of cows found to be tuberculous on post-mortem examination varies from 28 to 46 per cent, that for calves is under 1 per cent; for heifers, from 3 to 12 per cent; for oxen, 2 to 4 per cent; and for bulls 4 to 22 per cent, the latter depending, as in cows, upon the age of the animal.

The evidence of tuberculosis in cows as shown by the presence of tubercle bacilli in milk is of much less value as a guide to the incidence of the disease. The existence of tubercle bacilli in milk from a known herd indicates the presence of one or more open cases of the disease. The origin of tubercle bacilli in milk is usually an animal with a tuberculous udder, and this is the most serious form of the disease from the viewpoint of infection, as in the early stage of the disease the udder may appear to be normal although the milk contains tubercle bacilli, while the milk from the infected udder of one cow may contain a sufficient number of tubercle bacilli to infect the milk from thirty cows. The result of mixing milk is that although the infecting material is spread over a much larger bulk of milk the risk of massive infection is diminished.

Bovine tuberculosis, like human tuberculosis, is a generalized infection with a selective affinity for special organs, one of which is the udder, more especially in old cows which have borne the brunt of prolonged lactation. Primary udder disease does occur, but it is rare and is generally accepted as being due to direct external infection. The extent to which udder tuberculosis exists in ordinary dairy herds varies within narrow limits. Sir William Savage, who has collated the results obtained from various sources, gives a percentage of from 0·1 to 0·3 for clinical tuberculosis of the udder, but he considers that the percentage would be twice as high if all cases with tuberculous lesions were included. The figure of 0·5 per cent may, therefore, be accepted as an approximate estimate of the incidence of udder tuberculosis.

The extent of milk infection with tubercle bacilli varies in different districts according to the grade of milk. Pullinger gives some striking figures obtained from investigations carried out with the inoculation test. Of 101 samples of milk from forty-five tuberculin-tested herds only one contained tubercle bacilli, whereas of samples from sixty-three 3,000-gallon rail-tanks which

were examined all were found to be contaminated with tubercle bacilli. One significant result obtained by Pullinger in his investigation relates to the extent to which milk had to be diluted before it lost its infectivity for guinea-pigs. He found that samples of raw rail-tank milk had to be diluted 10 to 1,000 times before infectivity was lost, and that samples of milk obtained from a cow with tuberculous udder retained its infectivity for guinea-pigs even when diluted one million times. In Scotland investigation has shown that in the four cities, Edinburgh, Glasgow, Aberdeen, and Dundee, samples of raw milk showed the presence of tubercle bacilli in 10 per cent. One significant result which emerges from this investigation is in regard to the excellent standard of milk from tuberculin-tested herds as regards freedom from infection with tubercle bacilli. Of 714 samples of milk from these herds which were examined, in only one were tubercle bacilli found. Figures given for various districts in this country show that the percentage of positive findings in the case of mixed milk samples prior to the year 1928 varied from a minimum of 1·3 to a maximum of 15·2 per cent; more recent figures give a range varying from 2 to 21 per cent. It is estimated that the average for the whole country of samples of milk containing tubercle bacilli is about 7 per cent.

One of the main difficulties which the milk problem in relation to tuberculosis presents is the wide difference which exists between the incidence of infection and the proportion of animals detected as being infected on routine veterinary inspection. According to returns from various districts collected by Sir William Savage, the incidence of clinical tuberculosis in dairy herds detected on routine veterinary inspection varies from 0·15 to 1·77 per cent.

The reason for the wide variation between the number infected and the number presenting recognizable clinical lesions is that apart from the tuberculin test it is difficult to diagnose the presence of tuberculosis in an animal in the absence of gross lesions. This is the explanation why an animal may continue to pass tubercle bacilli in the milk for a considerable period without detection and is the reason for the delay which may occur in finding the animal or animals responsible when tubercle bacilli have been found in mixed milk.

CAUSES AND TYPE OF INFECTION. The high incidence of tuberculous infection in cattle depends upon two main determining factors, namely, extreme susceptibility to a specific organism and the existence of continued facilities for infection. The much higher incidence in dairy cows compared with that in bulls, heifers, and oxen, is due to lowered resistance occasioned by close confinement, frequent calving, prolonged lactation, and the greater risk of infection. Calves born of tuberculous cows are usually free from infection and will remain so if removed from contact with infected animals and are fed with milk which does not contain pathogenic tubercle bacilli.

The various breeds of cattle are not all equally susceptible; some South African breeds are stated to possess a relatively higher resistance, but in estimating the relative resistance or susceptibility of various breeds it is impossible to exclude the influence of other contributory factors. It should be possible, however, to evolve a breed which possesses a higher degree of resistance to tuberculosis than is possessed by the common breeds found in dairy herds at the present time. Too much importance must not be attached to the position of the cowshed as an aetiological factor, as it has been shown that among breeding cows kept in the open all the year round in Queensland the ratio of reactors to the tuberculin test was between 30 and 40 per cent. The character of the food given to dairy cows is also one which exercises influence on the degree of resistance; the present aim of feeding is to increase the production of milk, but increasing attention is being paid to improved nutrition with increase in the resistive powers of the animal.

The method of infection in cattle is by coarse droplet infection or by the ingestion of infected milk or indirectly through the medium of infected dust or infected pasture. Coarse droplet infection must be a frequent cause of the disease in the cowshed, especially when cows are placed head to head without any intervening protection. Infection by ingestion is the main cause of the disease in calves and young animals. The extent to which infection in calves may be produced by feeding with infected milk is shown by the results of an investigation by Wilkie *et al.* for the Hannah Institute of Dairy Research. Two groups of calves, seventy-three in number, were fed for a period of twelve

weeks on raw and pasteurized milk obtained from the same source, namely, mixed milk from untested herds; thirty-seven calves received pasteurized milk, and thirty-six had raw milk. Of the calves fed on pasteurized milk only one reacted to the tuberculin test, but no positive evidence of tuberculous infection was discovered in this case on post-mortem examination or by the inoculation of glandular material into guinea-pigs. Of the thirty-six animals fed on raw milk, twenty-four reacted to tuberculin, and in twenty-three evidence of tuberculosis was found on post-mortem examination. The post-mortem findings were as follows: tuberculous bronchial glands 4, tuberculous bronchial and mediastinal glands 3, tuberculous bronchial glands and pulmonary infection 11, tuberculous bronchial and mediastinal glands and pulmonary infection 5. One of the most interesting and significant results obtained by this research is the proof that the main infection occurred in the bronchial glands and in the lungs, and that no microscopic evidence of disease was found in the mesenteric glands. It confirms the view which has been held for many years that ingested bacilli find their way eventually to the lungs and bronchial glands without producing tuberculous lesions in abdominal structures.

The relative extent to which infection in dairy cows is produced by dust and by polluted pasture is difficult to estimate. In dark insanitary cowsheds in which little attempt is made at cleanliness, infected dust must constitute a real source of danger either by inhalation or by the ingestion of infected foodstuffs. Infection from pasture contaminated by excreta containing tubercle bacilli is also a possible cause of the disease and must be the explanation of the infection found in animals which live continually in the open and in wild deer which gain access to the feeding-grounds of cattle. The extent to which cattle are permitted to graze on polluted pasture must therefore be considered in relation to the relative incidence of infection. That the bovine tubercle bacillus remains viable in soil and in dung has been proved by investigations carried out by the National Institute of Research in Dairying. It has been demonstrated that organisms recovered from polluted pasture proved pathogenic to guinea-pigs after exposure for a period of six months. From a study of disease in wild animals and birds the salient fact emerges that when overcrowding

and the excretal pollution of feeding-grounds occur the health suffers and disease makes its appearance, and this is the probable explanation of the appearance of tuberculosis in wild voles. Whether the disease is due to an existing source of infection or develops *de novo*, it is impossible to state, but it would be an interesting investigation if it were practicable to test the continued freedom from infection of a herd of tuberculin-negative cattle feeding on virgin pasture which gradually became grossly polluted and from which all possible contact with any source of outside infection were eliminated.

In this connexion the absence of tuberculosis in cattle in Jersey presents an interesting study; in that island bovine tuberculosis does not exist. The writer is indebted to Dr. Marett, the Medical Officer of Health, for the following information on various points relative to the question. The landing of cattle on the island is prohibited not for prophylactic reasons but with a view to maintaining a pure Jersey strain. The cowsheds are ancient and are badly lighted and poorly ventilated, and here we have a definite illustration of the absence of any correlation between insanitary cowsheds and the incidence of tuberculosis. The cattle are out of doors at pasture almost all the year round, the custom being to allow one vergee (about one-fifth of an acre) of pasture per cow per annum. The cows are tethered to prevent them trampling and wasting the grass on which they feed, and although there is naturally some fouling of the pasture the animals work gradually across the meadows. An interesting point which might well call for further investigation relates to the methods adopted to promote the enrichment of the pasture. The contents of the liquid-manure cisterns which undergo anaerobic treatment are used for this purpose, but owing to the strength of the liquid manure it is only applied to the land when raining. In addition, seaweed is used as a fertilizing agent for land and pasture, and in Dr. Marett's opinion the iodine contents of seaweed is a factor to be considered in relation to the freedom of the cattle from tuberculous infection. The extent of the freedom from tuberculosis in Jersey is shown by the figures on page 116.

The tuberculin test is applied only when animals are being exported, and not at stated intervals. All reactors are killed and the carcasses examined. Of the seven reactors in these

groups the test was doubtful in three animals and positive in four. Post-mortem examination of the four positive cases did not reveal any definite evidence of tuberculosis.

Year	Number of Animals tested with Tuberculin	Reactors
1933	60	–
1934	88	–
1935	177	1
1936	398	2
1937	482	4

Several points of interest arise in connexion with the absence of tuberculosis in cattle in Jersey. The main protective factor is the exclusion of infected animals, and there appears to be no evidence of any tendency for the disease to develop *de novo*. Is this explained by the methods adopted in connexion with grazing and the fertilizing of the pasture grounds? The animals are continuously in the open, the method of tethered grazing which is adopted minimizes the extent of excretal contamination, and although the contents of liquid-manure cisterns are used for fertilizing purposes, seaweed is also applied for the same purpose. Bardswell, in his comprehensive survey of tuberculosis in Cyprus, stated that the incidence of non-pulmonary clinical infection in that island is relatively low and that bovine infection in the native breed of cattle is practically unknown, no reacting animal having been found for several years. On the other hand it is interesting to note that avian infection of turkeys and fowls is quite prevalent and that pigs are occasionally infected with this strain of organism.

Tuberculous infection in cattle is invariably due to the bovine type of bacillus, although occasionally infection with the avian type of organism has been reported. Existing evidence favours the view that the primary focus of infection, as in the human subject, occurs in the lungs. The infection is essentially chronic in character and the disease spreads by continuity of tissue or by metastasis to extra-pulmonary organs and structures of which the lymphatic system, the udder, and the uterus are chiefly involved.

The incidence of pulmonary infection in cases of udder tuberculosis is shown by Winkel's figures for the Netherlands.

1906. Of 222 cases of udder tuberculosis, 91·1 per cent had pulmonary infection.

1907. Of 335 cases of udder tuberculosis, 91·7 per cent had pulmonary infection.

The analogy between bovine tuberculosis in cattle and human tuberculosis in man is that in both the disease is a general infection originating with few exceptions from a primary focus in the lung with metastatic outcrops in various extra-pulmonary organs and structures. The difference between the two is that in cattle the disease is more chronic in character; the extra-pulmonary structures which bear the brunt of the metastatic infection include the udder and uterus, and in cattle there exists a correlation between advanced age and progressive and widespread lesions.

DIAGNOSIS OF TUBERCULOSIS IN CATTLE. As is the case with tuberculosis in the human subject, the diagnosis of tuberculosis in cattle is directed towards the detection of infection and the existence of open lesions from which tubercle bacilli are being expelled. The early diagnosis of infection, and especially the early recognition of open lesions, are of primary importance from the point of view of preventing the extension of the disease in the herd and of preventing the bacterial contamination of milk.

The double intra-dermal test is now generally employed for the detection of tuberculous infection in cattle. The following is the correct procedure to adopt in applying this test. After shaving or clipping the hair and measuring the thickness of a fold of skin with calipers, 0·1 c.c. of old tuberculin is injected deeply into the derma of the skin near the middle of the neck. After forty-eight hours, if the test is positive, swelling, heat, and tenderness are present at the site of infection and the thickness of the fold of skin is again measured. With a positive reaction the normal measurement of the fold, which is 6 to 8 mm., becomes increased to 22 to 33 mm. If in place of marked swelling with heat and tenderness there is a hard bean-like infiltration of the derma a second injection is given, the point of the needle being directed into the centre of the infiltration, and after the lapse of twenty-four hours the result is noted.

The ophthalmic test may be used to confirm the results of the intra-dermal test, but as a single test it is not reliable. The test is carried out by instilling one drop of undiluted old tuberculin into the conjunctival sac, followed by a second installation of two to five drops forty-eight hours later; if the result is positive a conjunctivitis occurs after twenty-four hours.

A positive response to the tuberculin test, while it indicates the existence of tuberculous infection, does not necessarily prove the existence of open tuberculous lesions, although all reactors must be regarded as potentially open cases of infection. The presence of clinical tuberculosis in animals is confirmed by the finding of tubercle bacilli in the milk, in the faeces, or in the secretions obtained from the trachea.

The microscopic examination of milk for tubercle bacilli is made by staining films prepared from the deposit obtained by centrifuging a sample of the suspected milk in narrow tubes. A positive film result in a sample of mixed milk indicates somewhat gross contamination. A negative result cannot be accepted as indicating the absence of tubercle bacilli in the sample. The microscopic test increases in reliability as the source of the milk examined is narrowed down to a small group of animals and finally to a single animal.

Mary Maitland recommends the following method for the rapid detection of tubercle bacilli in milk by the direct film method. The milk is centrifuged at 2,500 revolutions per minute for three minutes, the supernatant milk is decanted and the deposit is spread on a slide, dried in hot air for half an hour, and fixed in the flame. The slide is then placed in equal parts of alcohol and ether for fifteen minutes to remove fat, after which the film is stained with hot carbol-fuchsin for eight minutes. The film is washed and decolorized in 3 per cent hydrochloric acid in alcohol for three minutes, washed and decolorized in fresh acid alcohol for three minutes, washed and counter-stained with Loffler's methylene blue for two minutes. The author states that the results she has obtained by this method are comparable with those of biological examination.

The cultural method may be employed for the detection of tubercle bacilli in milk, although considerable difficulty is experienced in eliminating acid-fast saprophytes. Green, who has

employed this method and has checked his positive findings by means of the inoculation test in guinea-pigs, gives the following results. In seventy-seven samples of milk examined by him sixty-one were negative, four were positive to both the cultural and inoculation test, three were positive on culture examination and negative on animal inoculation, but the pathogenic character of these strains was subsequently confirmed, and nine were positive to animal inoculation but were negative on cultural examination. These results provide proof of the value of animal inoculation in the detection of the presence of tubercle bacilli in suspected milk.

While the demonstration of the presence of tubercle bacilli in the milk confirms the diagnosis of tuberculosis, the presence of other abnormal elements in the milk has been investigated with a view to providing a possible aid to diagnosis. Sir William Savage states that the variations in the cellular content of milk which occur in udder tuberculosis may possibly be of value, although in studying the cellular deposit he has not found any special types of cells which have proved of reliable diagnostic assistance. McFadyean draws attention to the plasma cells stained by Pappenheim's stain as of importance. Kulhmann has carried out investigations as to various methods of detecting udder tuberculosis in cattle, which included microscopic examination under a low power of milk deposits from individual udder and individual quarter samples for giant cells and the examination of milk whey by the complement fixation test. In 117 samples of milk from animals positive to the inoculation test tubercle bacilli and giant cells were found in 106. Of 186 similar samples examined, the complement fixation test was positive in 129; this test is sometimes positive in the absence of udder tuberculosis. Kulhmann's conclusions in regard to these findings as applied to single cow samples are that the presence of giant cells, plus a positive complement fixation milk test, indicates tuberculous infection of the udder, and where both are negative the disease is absent.

The biological test provides a much more accurate if more protracted method of detecting tubercle bacilli in milk. The test is carried out by the inoculation of a guinea-pig subcutaneously or via the peritoneum with the deposit obtained by centrifuging

a quantity of the suspected sample. Sir William Savage has recommended the procedure of using 100 cc. of milk centrifuged for one hour at 3,500 revolutions and inoculated subcutaneously into one guinea-pig. The test is positive if evidence of tuberculous infection is found on post-mortem examination when the guinea-pig is killed four to five weeks after inoculation. Possible sources of error may arise if the guinea-pig succumbs to some intercurrent infection or has developed tuberculosis otherwise than from the inoculated material or develops some condition somewhat simulating tuberculous lesions such as coccidiosis.

When tubercle bacilli are found to be present in a sample of mixed milk the detection of the cow or cows at fault may present considerable difficulty. The experienced veterinary surgeon institutes a combined clinical and bacteriological investigation which aims at narrowing down to a small group of animals, and finally to the animal or animals which are at fault. The clinical investigation should embrace a general survey of the animals in the open and a careful examination of the animals in the cowshed. The detection of a definite udder lesion may at this stage indicate the animal responsible. In the absence of any definite udder lesion attention has to be directed to any animal with a doubtful udder or any animal with symptoms of pulmonary disease, or which has shown evidence of ill health. The dictum that an extra-pulmonary tuberculous lesion means pulmonary involvement in the great majority of cases must always be kept in mind. The symptoms of pulmonary tuberculosis are chronic cough, lassitude, and wasting, or at least some fineness of outline, especially affecting the fore-quarters.

The detection of the animal responsible by the finding of tubercle bacilli in its milk may be a slow process in a large herd in the absence of any definite evidence of disease. If difficulty is experienced small group samples should be taken, each group sample including milk from two or three animals. If an infected group be discovered the examination of single cow samples will readily indicate the offending animal. An intelligent cowman who has knowledge of the animals and their state of health, and who is willing to assist in the investigation, an important consideration, may be helpful by indicating an animal or animals of which he has reason to be suspicious. The existence of

pulmonary lesions may be confirmed by positive findings in the sputum obtained from the suspected animal by inserting a cannula into the trachea through which a brush is introduced.

The biological test provides a delicate measure of the presence of living tubercle bacilli in milk. Various investigators have shown that the inoculation of as few as two to six tubercle bacilli will induce infection in guinea-pigs whatever the source of the organism.

CONTROL AND PREVENTION. Within recent years much study has been given to the most efficient and practicable measures to be adopted with a view to the control of tuberculous infection in cattle and the prevention of infection with the bovine type of tubercle bacillus in man. While the standard of milk generally as regards freedom from infection with tubercle bacilli of bovine origin is much higher than it was twenty or thirty years ago, there is still much ground to cover before a satisfactory standard of milk purity is reached. It is necessary in considering the question of a pure milk supply to take a broad view and to have regard to the existence of organisms other than the bovine tubercle bacilli, such as organisms of the streptococcal group, the specific organism of contagious abortion, and other pathogenic bacteria which are responsible for characteristic infections of a serious character in man. The result which is aimed at is to deliver milk to the consumer free from infection with pathogenic bacteria and to provide that the methods adopted in the production of milk and in its passage from the cow to the consumer should be such as to secure this desirable result.

The measures which have been considered or adopted with a view to the elimination of tuberculous infection through milk include the following:

(1) Raising the resistance of cattle to infection.

(2) Improving hygienic conditions of cowsheds and pasture land.

(3) The detection and elimination of reactors.

(4) The detection and elimination of animals with clinical tuberculosis.

(5) The protection of milk in transit from cow to consumer.

(6) The treatment of milk to destroy pathogenic organisms.

RESISTANCE TO INFECTION. The resistance of cattle to primary tuberculous infection is low, but the chronicity of the disease and the high incidence of non-clinical reactors suggests that similarly as in man, primary infection exercises some degree of specific protection against rapid and progressive development of the disease. The possibility of inducing specific protection by inoculation in cattle has been the subject of continued investigation, but no results of any positive value in this direction have so far been obtained. The possibility of developing a breed of cattle possessing higher resistance to tuberculosis is worthy of exploration; all breeds do not appear to be equally susceptible. du Toit states that the post-mortem findings of over a million cattle slaughtered in Johannesburg during the years 1917 to 1929 showed that in only 0·031 per cent were tuberculous lesions found, and that during the same period, of cows chiefly belonging to native and African breeds, only 0·152 per cent showed evidence of tuberculous infection. Reports from various districts of Africa indicate that tuberculosis when detected is chiefly met with in imported cattle, and that indigenous animals, notably the African zebu and the Ankole cattle, are much more resistant. If the low incidence of the disease in these breeds be due to a higher natural resistance and not to the absence of exposure to infection, it suggests a line of investigation which might prove of practical value, but whether a higher degree of immunity is compatible with a continued demand for high milk production is open to question.

The B.C.G. vaccine of Calmette and Guérin which is prepared from an attenuated bovine strain of tubercle bacillus has been extensively employed with a view to promote specific protection. Irvine, who has made a careful survey of the experimental work carried out with B.C.G. vaccine, and who gives a summary of the results obtained by various investigators abroad, states that the majority of these investigators report favourably on the protective value of the vaccine for cattle.

The investigations carried out in this country have not, however, confirmed the results obtained by investigators abroad. Stanley Griffith, who has tested the protective value of B.C.G. in the rhesus monkey, arrived at the following conclusions:

(1) The strain of B.C.G. used in these experiments can produce local lesions in the rhesus monkey, but these are always benign and do not lead to generalization.

(2) B.C.G. given by the mouth can pass through the mucous membrane of the alimentary canal into the adjacent glands and also gain access to the blood stream.

(3) Vaccination with B.C.G. whether by feeding or by injection has failed to give to monkeys complete protection against tuberculosis, but in some instances may have produced a low grade of relative immunity.

The extent to which immunity is induced in calves by B.C.G. has been investigated by Stanley Griffith, Buxton, and Glover, and the results which they obtained indicate that while a double intravenous injection of this vaccine gives complete protection for six months to the oral administration of virulent strains of the tubercle bacillus, the protection is only temporary in character, and after nine and twelve months progressively declines, and further, that revaccination does not completely control the declining immunity. The conclusion they draw from their investigation is that the intravenous injection of B.C.G. vaccine is capable of producing an effective resistance of limited duration. A somewhat similar negative result has been obtained by Watson after a series of investigations extending over a period of five to six years. Spahlinger's simplified dead vaccine has also been employed with a view to secure active immunization in cattle, and its value for this purpose has been the subject of a somewhat extended investigation in Northern Ireland. The report on the experimental work carried out states that the inoculation of calves with Spahlinger's new vaccine conferred upon them a high degree of specific protection against massive doses of tubercle bacilli administered intravenously. This report has been considered by the Joint Committee on Tuberculosis, who have expressed the opinion that a case has been made out for further investigation as to the specific action and possible value of this vaccine as an immunizing agent for the protection of cattle against tuberculosis. In the present state of our knowledge, however, regarding its specific action, they do not recommend its general use. It is important that experimental work on the immunization of cattle against tuberculosis, however inconclusive the results

may have been up to the present time, should be continued on a wider scale. In the light of our present knowledge regarding infection and immunity in relation to tuberculosis it is not difficult to envisage the possibility of inducing not temporary, but permanent immunity in cattle against tuberculosis which may indicate the method to be adopted in securing specific protection in the human subject against the disease.

HYGIENIC CONDITIONS OF COWSHED. The sanitary and hygienic conditions of cowsheds are of importance in relation to the health of cows and the prevention of tuberculous infection. The cowsheds should be well constructed and airy, and be so designed as to facilitate cleaning and periodic disinfection; adequate light and ventilation are essential. From the point of view of prevention preference should be given to single stalls on one side only, although questions of inconvenience and increased cost may arise; open head-to-head stalls should obviously be avoided. The avoidance of overcrowding and the provision of adequate ventilation are important considerations. Buchan points out that the proportion of skin surface to weight in the cow is much less than in the case of man, and that it is necessary to have freer circulation of air about the former than about the latter. Measurements recommended are: floor space, 50 square feet; height, 15 feet; cubic space, 800 cubic feet; change of air, nine times per hour; area of inlet ventilation, 80 square inches; the latter being placed 5 to 6 feet from the floor-level. Inlets for ventilation in cowsheds may be provided by curved drain-pipes, air-bricks, gratings, or other means. Outlet ventilation is essential and may be provided in the form of an extraction cowl or by an opening along the length of the building; the outlet area of ventilation should exceed the inlet. Adequate natural lighting is essential and should be provided by wall windows and top lighting so that sunlight may reach every corner of the cowshed; three square feet of window surface per cow should be provided as a minimum.

Cleanliness of the cowshed and facilities for the ready removal of excreta are important factors in relation to the prevention of tuberculosis. Floors should be constructed of durable and impervious material, walls should have a hard smooth facing to a height of 5 feet, and all corners and angles should be rounded

so as to facilitate cleaning. The length of the standing should be from 5 feet to 5 feet 6 inches, so as to prevent fouling, and the floor should have a slope of 1 in 80 to the drainage channel. This channel should be 18 to 24 inches wide, and should have a slope of 1 in 240 and should discharge into a trapped gully outside the building.

The approach to the cowshed requires careful and continued attention. A damp and muddy approach contaminated by excreta is a frequent cause of plashing with consequent soiling of the animals' legs and udder. The approach must be constructed of material which will provide a dry surface and all faecal collections should be removed. All manure must be removed to a considerable distance from the cowshed and dairy, and should be so protected as to prevent it fouling animals going to and coming from the cowshed.

Cleanliness of the milkers and of the animals they milk is also of importance in relation to clean milk and to freedom from contamination with organisms of the coliform group and with pathogenic bacteria. Conditions as to cleanliness of animals, milkers, and cowshed, are laid down in the Milk and Dairies Order, 1926, made under the Milk and Dairies Consolidation Act, 1915, and the Milk and Dairies (Amendment) Act, 1922. The two Acts mentioned above are repealed by the Food and Drugs Act, 1938, which comes into operation on October 1st, 1939. This Act provides for the replacement of the Milk and Dairies Orders by Milk and Dairies Regulations, and Section 20 empowers the Minister of Health to make regulations for certain specified purposes which include *inter alia* (1) precautions to be taken to protect milk against infection or contamination, (2) prohibiting the sale of infected, contaminated, or dirty milk, or of milk suspected of being infected, (3) imposing obligations on dairymen and their employees in regard to cases of infectious disease, and (4) preventing danger to health from the importation of milk. Section 22 of the Act empowees the authority by whom dairymen are registered, if they have reason to believe that the public health is likely to be endangered by an act or default of a person, to serve a notice on such person with a view to investigating the matter. Article 6 of the Order of 1926 imposes upon every sanitary authority the duty of keeping a register of all

cow-keepers and dairymen and of all farms and other dairy premises and of notifying the County Council of all particulars of registration and of alterations made in the register. Article 12 provides that every cowshed and every building used for keeping milk shall have sufficient light, that openings for efficient ventilation shall be provided and maintained, and that during the hours of darkness adequate artificial light should be available. Under Article 13 all registered premises are to have a suitable and sufficient water-supply protected as far as reasonably possible from contamination with foul or polluted water. Article 15 lays down that every person engaged in the milking of cows or handling of milk shall keep his person and clothing in a clean condition. Article 22 provides for the cleansing of the interior of cowsheds from time to time and for the lime-washing or spraying with lime or other disinfectant of the interior of the roof and walls of the cowshed at least twice a year. All dung and offensive material has to be removed at least once a day. Article 23 lays down that the milking of cows must be carried out in a good and proper light, and that before milking all dirt in or around the flanks, udder, and teats of each cow shall be removed and the udder and teats cleansed. The hands of the milker are to be thoroughly washed and dried before milking and are to be kept clean, free from contamination, and, as far as practicable, dry; all milking stools are to be kept thoroughly clean. As soon as possible after milking the milk from each cow is to be removed to a suitable milk-room or be placed in a covered receptacle.

While the sanitary and hygienic standard maintained in the cowshed is of importance in relation to the health and protection of cattle the risk of infection which arises from the pollution of pasture and water cannot be disregarded. Certain facts which have previously been mentioned serve as pointers to this possibility. The overcrowding of feeding-grounds should be avoided and the fouling of pasture-land should be reduced to the lowest possible minimum. A pure water-supply must be provided; it is still not uncommon to see cows drinking pond-water in which they are standing and which at the same time they are fouling. To avoid the gross pollution of pasture-land the system of the rotation of feeding-grounds might be more extensively and more scientifically adopted. There are other precautionary measures

which suggest themselves, but it is not necessary to discuss them further. What is to be aimed at is a clean cow, relatively unpolluted pasture-land, and a water-supply of a satisfactory standard of purity.

DETECTION AND ELIMINATION OF REACTORS. This method is adopted in certain states in America and in Canada. By the elimination and slaughter of animals reacting to the intra-dermal test and by restricting additions to the herd to non-reactors, it is possible to build up and to maintain a herd free from tuberculous infection and to establish in due course an 'accredited area' which contains a group of tubercle-free herds. This method is the most reliable and efficient system of securing the elimination of tuberculosis, and should be adopted in those countries in which the ratio of reactors is low, but for economic reasons it is not generally practicable where the ratio of reactors is high, as in this country, except by a gradual process.

The detection and elimination of reactors has been adopted by Bang of Copenhagen in the system which he advocates for the building up of a herd free from infection. His method includes (*a*) the clinical examination of all animals and the slaughtering of any showing clinical evidence of disease; (*b*) the testing with tuberculin of the remaining animals; (*c*) the separation of reactors from non-reactors and their continual separation as far as is practicable; (*d*) the removal of calves from all contact with infected animals and the feeding of calves with milk treated to destroy any tubercle bacilli which may be present; and (*e*) the testing of the herd and calves twice yearly with tuberculin and the elimination of reactors.

In the Report of the Agricultural Research Council attention is drawn to the fact that it has been repeatedly demonstrated that herds free from tuberculosis can be established and maintained by regular testing, elimination of reactors, disinfection, and isolation, and by the testing and quarantine of newly introduced cattle.

DETECTION AND ELIMINATION OF ANIMALS WITH CLINICAL TUBERCULOSIS. The presence of clinical tuberculosis in dairy animals may be detected during routine veterinary inspection or as a result of finding tubercle

bacilli or securing a positive biological test in a sample of milk or for the reason that the owner or cowkeeper has recognized the existence of a tuberculous animal or has a suspicion that an animal appears to be suffering from the disease.

Section 25 (1) of the Food and Drugs Act, 1938, provides that no person shall

> (*a*) sell or offer or expose for sale for human consumption, or
> (*b*) use in the manufacture of products for sale for human consumption the milk of any cow which to his knowledge has given tuberculous milk, or is suffering from emaciation due to tuberculosis, or from tuberculosis of the udder or any other disease of cows.

(2) In proceedings under this section the defendant shall be deemed to have known that a cow had given tuberculous milk or was so suffering if he could with ordinary care have ascertained the fact.

The action taken by Medical Officers of Health to stop a milk supply and to take steps to have suspected animals examined under Sections 3 and 4 of Milk and Dairies (Consolidation) Act, 1915, has been altered by the Agriculture Act, 1937, and the Tuberculosis Order, 1938. The new arrangements provide, when the Medical Officer of Health of a county or county borough receives notice that milk is, or is likely, to cause tuberculosis, he shall communicate with the Divisional Inspector of the Ministry of Agriculture and Fisheries, who will arrange for the inspection of the cattle concerned and proceed as if the notice had been received under the Tuberculosis Order, and will inform the Medical Officer of Health of the result of the investigation.

The routine inspection of cattle is carried out under the Milk and Dairies (Amendment) Order, 1938, which revokes Articles 8, 9, and 10 of the Order of 1926, which relate to the inspection of cattle. These inspections are now carried out by the divisional inspectors appointed by the Ministry of Agriculture and Fisheries.

The tuberculin testing and veterinary examination of cattle for the purpose of the Milk (Special Designations) Orders, 1936 and 1938, are also carried out by divisional inspectors. This transfer of functions does not, however, affect the existing powers of Local Authorities to grant licences authorizing the use of the

designations 'tuberculin tested' and 'accredited' in England and Wales and 'certified', 'tuberculin tested', and 'standard' in Scotland.

The Milk (Special Designations) Amendment Order of 1938 provides *inter alia* that

(1) A producer applying for a primary licence to use the designation 'tuberculin tested' shall either satisfy the licensing authority that the herd is an attested herd or that every animal in the herd, not more than one month previous to date of application has been subjected to a tuberculin test made by an inspector or furnish the authority with a certificate that such test has been carried out.

(2) He shall satisfy the authority that every animal has been clinically examined by an inspector not more than one month previous to date of application or submit a veterinary surgeon's certificate to the effect that such examination has been carried out.

(3) He shall satisfy the authority that any animal certified as reacting to tuberculin or any animal showing evidence of diseases likely to affect the milk injuriously shall be removed or segregated from the herd.

(4) Where a producer applies for a primary licence to use the special designation 'accredited' he shall either satisfy the authority that the milch cows in the herd have been examined by an inspector not more than one month previous to date of application or furnish a veterinary surgeon's certificate to the effect that such examination has been carried out. Any cow showing evidence of any disease shall be removed or segregated from the herd.

(5) Examinations and tuberculin tests shall be made by an inspector unless otherwise agreed.

(6) An inspector may make a special tuberculin test of any animal at an interval of not less than two months after the last preceding test or at any time if the animal has not been previously tested.

(7) Every animal belonging to a "tuberculin-tested herd" shall be examined at intervals of not more than six months and if the examination is made by a private veterinary surgeon his certificate thereof shall be sent to the licensing authority within seven days after the date of examination.

(8) Every milch cow belonging to an 'accredited herd' shall be examined once in every three months and if the examination is made by a private veterinary surgeon his certificate thereof shall be sent to the licensing authority within seven days after the date of examination.

The action to be taken following the detection of an animal suffering from tuberculosis or of an animal which appears to be

affected with the disease is laid down in the Tuberculosis Order, 1938. This order provides *inter alia* that:

(1) (i) Every person having in his possession or under his charge:

(*a*) any cow which is, or appears to be affected with tuberculosis of the udder, indurated udder, or other chronic disease of the udder; or

(*b*) any bovine animal which is or appears to be affected with tuberculous emaciation; or

(*c*) any bovine animal which is affected with a chronic cough and showing definite clinical signs of tuberculosis

shall with all practicable speed give notice of the fact to a constable of the police force for the area wherein the animal is, or to a veterinary inspector which means a veterinary inspector of the Ministry of Agriculture and Fisheries. Paragraph (3) of this Article provides that a veterinary surgeon who, in the course of private practice, is of opinion or suspects that an animal which he has examined is an infected animal for the purpose of this Order shall without delay give notice of the fact to a constable or a veterinary inspector. Paragraph (4) imposes upon the constable receiving any notice under this Article the duty of giving information of the receipt of such notice to the veterinary inspector of the area where the animal is and to an inspector of the Local Authority which is the Local Authority for the purposes of the Diseases of Animals Act, 1894. Any person who is in possession or has charge of a bovine animal which is or appears to be infected with tuberculosis must take certain precautions to prevent the spread of infection. Article (2), paragraph (3) provides that when a notice is served under paragraphs (1) or (2) of this Article the owner or person in charge of the animal must detain the animal on premises specified and keep it isolated from other bovine animals. It is also required that in the case of a cow the milk shall not be mixed with other milk until a Withdrawal of Notice (Form B) has been served and that all milk affected by the Notice (Form A) shall be boiled or otherwise sterilized. Any utensil in which such milk has been placed before being sterilized must be thoroughly cleansed and scalded with steam or boiling water.

Where the report of the veterinary inspector indicates that there is an infected animal on the premises Article 4 (1) lays down that the veterinary inspector shall give notice in writing (Form C) to the owner or person in charge of the animal and shall cause the animal to be slaughtered. Objection on the part of the owner may be submitted in writing to the Minister or the veterinary inspector and the animal shall not be slaughtered until further special authority under the Official Seal of the Minister has been obtained. Article 5 (1) makes it obligatory for a

post-mortem examination to be carried out in the case of every animal slaughtered under the provisions of Article 4 of the Order.

The principle underlying this Order is similar to that in the method advocated by Ostertag of Stuttgart, which includes (*a*) the clinical examination of all animals to discover open cases of the disease and the slaughter of animals so infected; (*b*) the periodical bacteriological examination of samples of milk from the herd; (*c*) the feeding of calves with sterilized milk or with raw milk from cows which are free from infection with tubercle; and (*d*) the weaning of calves which are tested with tuberculin and the slaughter of those which react.

PROTECTION OF MILK IN TRANSIT. Milk after it has left the cow may become infected with tubercle bacilli of bovine origin from dust, especially in the cowshed or with tubercle bacilli of human or bovine origin by the employment of a person with open tuberculosis in the handling of milk and of the utensils which contain it. Infection of milk in the home from a case of pulmonary tuberculosis is by no means a remote possibility. The prevention of infection of milk in transit consists in the strict adoption of the simple measures of cleanliness and protection by sealing and covering. Too much importance cannot be attached to the cleansing and sterilizing of churns and other receptacles in which the milk is placed for conveyance to the consumer. The provision of an efficient sterilizing plant is essential to the continued production of clean milk. The risk of infection arising from the presence of a human carrier has been recognized. Article 4 of the Public Health (Prevention of Tuberculosis) Regulations, 1925, places upon Local Authorities the power to prohibit any person suffering from tuberculosis of the lungs from being employed in any occupation which involves the milking of cows, the treatment of milk, or the handling of milk vessels. The person concerned has a right of appeal to a Court of Summary Jurisdiction and he may obtain compensation if he has sustained damage and if he himself is not in default. It will now be possible to issue regulations for this purpose under the Food and Drugs Act, 1938.

TREATMENT OF MILK. PASTEURIZATION. The aim of pasteurization, around which no little heated discussion has revolved, is to destroy the pathogenic organisms

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present in milk so as to render it innocuous for human consumption. The destruction of these organisms is brought about by raising the temperature of the milk to an adequate degree and for a sufficient period of time to secure the destruction of the bacteria. Various methods of pasteurization are adopted in different countries according to variation in temperature, and the duration of time employed in the process. In this country the method adopted is the one defined in the Milk (Special Designations) Order, 1936, which provides for the milk to be retained at a temperature of not less than 145° F. and not more than 150° F. for a period of not less than thirty minutes with immediate cooling to a temperature of 55° F. or lower; as applied to Scotland the cooling temperature is 50° F. or lower. The milk shall not be heated more than once.

In considering the value of pasteurization as a measure to be adopted for the prevention of infection with the bovine tubercle bacillus in man, two main points have to be discussed, namely, the reliability of the process and the effect which it may exercise on the nutritive standard of milk. The reliability of efficient pasteurization in effecting the destruction of bovine tubercle bacilli in milk has been demonstrated by various observers. In the laboratory it has been found that the tubercle bacillus in naturally infected milk is destroyed by exposure to a temperature of 59° C. (134° F.) for thirty minutes. This is supported by the findings of Wilkie and others in experiments carried out on the value of pasteurized milk in the feeding of calves which have previously been mentioned, the milk used being obtained from a local depot licensed to produce 'pasteurized' milk under the Milk (Special Designations) Order (Scotland), 1923.

Various other observers in this country and abroad, including Meanwell, Campbell Brown, Price, Pullinger, and North and Park have by a series of investigations confirmed these results, and it is now accepted beyond any possibility of doubt that efficient pasteurization of milk destroys pathogenic organisms in milk including the bovine tubercle bacillus. The effect of efficient pasteurization at a temperature of 140° F. for a period of from twenty to thirty minutes is to destroy tubercle bacilli in twenty minutes, typhoid bacilli in two minutes, the bacilli of diphtheria in one minute, dysentery bacilli in two

minutes, the micrococci of undulant fever in twenty minutes and the organisms of cholera in one minute. While the recorded outbreaks of epidemic disease of milk-borne origin have been invariably due to infection through raw milk, outbreaks of infectious disease associated with inefficient pasteurization have occurred. In Montreal in 1927 an outbreak of enteric fever with over 4,755 cases and 453 deaths occurred in which the cause was attributed to infection of the milk before entering the pasteurizing plant and the release of a considerable quantity of the milk without efficient pasteurization. In Glasgow in 1931 there was an outbreak of scarlet fever with 230 cases, which was considered to be associated with pasteurized milk, the cause being attributed to a mechanical defect in the plant. In the process of pasteurization, as in any other mechanical process operated by man, there must necessarily exist the possibility of an unexpected mechanical defect, or an error on the part of some person or persons operating the plant, but under licence and efficient inspection the possibility of error or breakdown is reduced to a minimum.

Sir Weldon Dalrymple-Champneyes has pointed out that failure to secure efficient pasteurization is due to several causes which relate both to the individual and the plant. The most frequent causes of failure to which he directs attention are:—lack of knowledge, failure on the part of manufacturers to insist on a rational 'lay-out' of the plant and to incorporate efficient automatic temperature-control devices, the construction of plants from units of different makes, failure of the Local Authority to insist on reasonable requirements for buildings, plants, and methods of operation and, lastly, inadequate knowledge and experience on the part of inspectors.

Various objections have been raised to pasteurization, most of which are more or less theoretical in character. The chief criticism is that the process of pasteurization reduces the amount of certain important constituents in the milk which seriously impairs its nutritive value. The only constituents which investigation has shown to be in any way impaired are vitamin C, calcium and phosphates. Vitamin C is partially destroyed, but the amount of this vitamin in milk is so small that a further diminution may be disregarded. Calcium exists in cows' milk in amount which is considerably in excess of the requirements of

the artificially fed baby, so that some diminution in its quantity in no way impairs the nutritive value of the milk. The actual results observed in children who have been given pasteurized milk do not support the view that it is lacking in essential constituents. Frank, who investigated the histories of 3,700 children in the United States, was unable to detect any variation in the height and weight of children receiving treated milk as compared with those receiving raw milk. The feeding experiments carried out on calves by Wilson *et al.* have not proved that any changes in the constituents in milk which may result from pasteurization are such as to impair the health of the animals. On the contrary the average increase in weight was slightly higher in the group fed on pasteurized milk, the increase being 62·94 per cent for this group compared with 61·18 per cent for the group fed on raw milk. The literature dealing with the subject of the effect of pasteurization on the nutritive value of milk has been reviewed by Stirling and Blackwood, and they were unable to find any conclusive evidence in support of the view that there existed any substantial degree of variation in the nutritive value of pasteurized as compared with raw milk. Wilson states that pasteurization, if efficiently carried out and controlled in practice by the phosphatase test, renders milk safe for human consumption and that pasteurization is to be regarded as the equivalent to the treatment of water by filtration and chlorination. The Ministry of Health in summing up the position states that 'subject to careful operation and scientific control, the process ensures a milk which is not only safe for consumption but also retains its food value practically unimpaired by the heat to which it is subjected'.

A further objection which has been raised to pasteurization is that it would tend to encourage indifference to the presence of tuberculosis in cows and that it would remove the incentive for the production of clean milk. The answer to this objection is that the adoption of pasteurization must in no way tend to restrict effort towards securing a high standard of health in dairy cows or minimize the importance of producing milk free from pathogenic organisms. The higher the standard of milk the easier and more effectively is it pasteurized. The transfer of various functions relating to inspection and the elimination of disease in bovine animals to inspectors employed by the Ministry of

Agriculture and Fisheries will, it is hoped, secure a sustained and increased effort to improve the health of dairy herds and lead to the eradication of disease.

A plea which has been entered in support of raw milk is that the ingestion of bovine tubercle bacilli gives some measure of specific protection against infection with the human type of bacillus in later years. There exist no scientific data in support of this view. As it is not practicable to control the degree of virulence or the number of bovine tubercle bacilli which are ingested with raw milk, it is impossible to forecast whether the result will be a mild innocuous infection, a local infection which may result in serious disfigurement or deformity, or a general intensive infection which may end fatally. This plea must therefore be disregarded as unscientific and dangerous.

As the value of pasteurization in destroying the pathogenic organisms in milk has been proved by scientific investigation, there remains to be discussed the most efficient and practical system of application to be adopted. Universal compulsory pasteurization cannot be regarded as a practicable procedure at the present time. Sir William Savage, who has made a special study of the subject, advocates an active policy towards securing the elimination of tuberculosis among dairy herds and that only cows free from tuberculous infection should provide the source of milk and milk products for human consumption, and that pending the eradication of bovine tuberculosis, pasteurization should be employed to provide a safe milk supply. Mixed milk may be responsible for the conveyance of disease other than tuberculosis to a large head of population. Streptococcal infection, undulant fever, and diseases of the enteric group illustrate diseases which have their origin in milk infection. The writer has had experience of an outbreak of 168 cases of paratyphoid fever caused by milk from a dairy which received supplies from nine farms. The origin of the outbreak was traced to one farm where the farmer's wife who washed the cloths through which the milk was strained was not only nursing a child with an unrecognized paratyphoid infection, but was herself a carrier of paratyphoid bacilli.

The granting of powers to Local Authorities to make pasteurization compulsory in their areas is a step which has now received

official sanction. The procedure recommended in the paper *Milk Policy* is 'that subject to certain conditions, any Local Authority shall be enabled to apply to the Minister of Health or Secretary of State for Scotland, for an order making compulsory the efficient pasteurization of milk sold by retail in its area'. The conditions laid down are that the Order shall not come into operation until two years after it has been made, that it shall not apply to milk from tuberculin-tested herds or to sterilized milk, and that it shall not apply for three years from the date of operation to milk retailed from dairies supplied from a single herd. The British Medical Association has advocated an enlightened policy to safeguard the milk supply which provides that 'Local Authorities shall be enabled, after a reasonable period of notice, to prohibit the sale in their areas of milk which is not from tubercle-free herds, or has not been submitted to approved treatment to render it bacteriologically safe'. The Association also recommends 'that only milk complying with the conditions required for the designations "Tuberculin tested" or "Pasteurized" or preferably both, can safely be consumed without boiling'. It will be observed in the light of what has been recommended above that the position regarding pasteurization has become clarified. The policy must be developed along the following lines:

(*a*) The enforcement by Local Authorities of the efficient pasteurization of all milk which is not obtained from tubercle-free herds.

(*b*) The maintaining of the highest possible standard of cleanliness and hygiene in milk production and distribution.

(*c*) Pasteurization to be carried out under registration and rigid inspection.

(*d*) Local Authorities themselves to undertake the pasteurization of milk at special stations under certain conditions.

The trend of legislation in regard to pasteurization is shown in the Pasteurization Orders contained in the first Milk Industry Bill submitted to Parliament. These Orders provide for power to be given to the Minister of Health, upon application from the Local Authority, to make an order prohibiting the sale of unpasteurized milk, to empower the Local Authority to undertake the pasteurizing of milk or to provide persons with premises

or plant or to make loans or grants of money to enable the pasteurizing of milk to be carried out, and to include in the Order the extension of pasteurization to cream. The provisions contained in Part VII of the Bill deal in a comprehensive manner with the question of pasteurization. If they were to come into operation they would, if efficiently and uniformly applied, constitute a definite advance in the direction of securing a milk supply which is bacteriologically safe.

Milk in relation to tuberculosis has to be viewed from two opposite standpoints. On the one hand it provides a perfect food rich in essential constituents, including fat in its most refined form which when taken in adequate quantities by children and young adults improves nutrition and thereby increases resistance to the development of clinical tuberculosis. On the other hand, milk is a medium which facilitates the conveyance of infection with tubercle bacilli of bovine origin to man. The policy to be adopted, therefore, is to provide an adequate supply of milk for human consumption which is rendered safe by securing the absence or destruction of the pathogenic organisms which are liable to infect it.

Chapter Six

THE IMPORTANCE OF EARLY DETECTION

IN the prevention and treatment of disease of an infectious or contagious character, early recognition of its presence is of primary importance. In connexion with the acute infections early detection is of special importance in relation to prevention owing to the short period of incubation and to the fact that the disease may be most infectious at the stage of onset. In the case of tuberculosis its early recognition both as an infection and as a clinical entity is of importance in relation to both prevention and treatment.

The chief source of origin of pathogenic tubercle bacilli of the human type is the sputum of patients with caseating tuberculous lesions of the lungs, and it is essential, if infection is to be controlled, that the presence of the disease should be detected at a stage before much caseation has developed. Early diagnosis is also essential to the successful treatment of the individual and to the restoration of working capacity. The extent of tissue destruction which exists and the amount of systemic infection and of consequent constitutional disturbance which are present at the time of examination, while they depend upon the mass and character of the dosage, are also related to the time which has elapsed between the onset of the disease and the date of examination. Infection with tubercle bacilli is at the onset a pure infection, but once the tuberculous lesion has become open, the intrusion of extraneous organisms takes place and a mixed infection with consequent serious constitutional disturbance results.

DIAGNOSTIC DIFFICULTIES. Notwithstanding the advance which has been made in diagnostic technique, the detection of tuberculosis in the early stage of its development still presents a problem of considerable difficulty. Except when due to massive dosage in a susceptible subject which gives rise to acute or generalized manifestations of infection, or when associated with some alarming symptom such as haemoptysis, the onset of tuberculosis is not usually accompanied by sufficient subjective evidence of ill health to compel the patient to seek medical

advice. The result is that many patients who suffer from the disease are found when first examined to have extensive lesions which seriously prejudice their prospects of recovery, while during a period of time which necessarily varies in duration they have constituted a source of infection to those with whom they have been in contact. A further difficulty which arises is that in the absence of confirmatory evidence of clinical infection as provided by the finding of tubercle bacilli in sputum, discharge, or other material, it may be impossible without a period of observation and investigation to state categorically whether clinical tuberculosis is or is not present. In general practice a routine system of examination of the sputum, with the adequate provision of facilities for investigation in doubtful cases, is essential if the percentage of missed cases is to be maintained at a low figure. Unless such a system of careful investigation is carried out it is unavoidable that a considerable percentage of missed cases at the first examination should occur, and even with experts missed cases are not altogether unknown. These facts are mentioned to emphasize the importance of careful examination and investigation in relation to diagnosis when dealing with such an insidious and ubiquitous disease as tuberculosis.

SIGNIFICANCE OF PRIMARY INFECTION. The frequency with which primary infection occurs in childhood, its relationship to subsequent clinical manifestations of the disease in later years, and the explosive character which it may present when postponed until adult life must be kept in mind in relation to diagnosis. In approaching the problem of the diagnosis of tuberculosis it is necessary to have in mind that the individual under examination may never have been infected, may have had a primary infection which has healed or may be the subject of clinical tuberculosis due to continued activity of the primary focus or to reinfection. The primary focus may not completely heal but remain latent for an indefinite period with some intermittent phases of ill health or recognized stigmata of infection without presenting a definite clinical picture of the disease.

The existence of primary infection which does not eventuate in typical clinical manifestations of the disease cannot definitely be determined without the aid of the tuberculin test, and sensitiveness to tuberculin is specific evidence of present or past infection. In

children, however, there are certain stigmata the presence of which should suggest the possibility of a primary tuberculous infection; these are: (*a*) enlarged lymph glands in the cervical and supra-clavicular regions, (*b*) enlarged veins radiating over one or both sides of the chest in front, and a festoon of dilated veins in the cervico-dorsal region behind, (*c*) long eyelashes and an excessive growth of fine hair on the back, (*d*) a dry skin with fine desquamation, (*e*) malnutrition, (*f*) erythema nodosum, and (*g*) unilateral flushing and inequality of pupils. Erythema nodosum has come to be recognized as a frequent cutaneous expression of tuberculous infection. Wallgren gives some significant figures regarding the association of this condition with tuberculosis. Of 800 Swedish children with erythema nodosum 95 per cent gave a positive reaction to tuberculin compared with 25 per cent among children in the general population. In a group of 362 children who had erythema nodosum and who were positive to tuberculin, 68·5 per cent were found to have definite clinical and radiological evidence of tuberculosis compared with 7·1 per cent in a reacting control group. In 133 children it was demonstrated that the cutaneous eruption developed simultaneously with the onset of sensitiveness to tuberculin.

A special type of tuberculosis associated with primary infection in children known as epituberculosis, the name first given to it by Eliasberg and Neuland, has been described. This type of the disease occurs in children who are tuberculin positive, and is characterized by a considerable area of pneumonic consolidation, usually in the right lung with enlargement of the mediastinal glands. The physical signs are those suggestive of lobar pneumonia, but in epituberculosis dyspnoea and general symptoms are much less severe, whilst its duration may extend to several months or even to one or two years; recovery usually takes place although cases terminating in fatal tuberculosis have been reported. The generally accepted view regarding the character of the pneumonic process in the lung is that it consists of an inflammatory and possibly protective reaction of lung tissue around a definite tuberculous focus. An interesting and informing light is shed on the aetiology of epituberculosis by the experimental work of Larson and Long. In a series of animals these observers inoculated directly into the lungs doses of purified tuberculin

protein. The inoculations gave rise to an inflammatory reaction consisting of interstitial cellular infiltration and exudation into the alveoli. It was noted that the reaction was more marked in allergic than in normal animals, and Larsen and Long suggest that the inflammatory changes thus produced were similar to those which characterize the early stages of tuberculous pneumonia.

Burton Wood, in a recent contribution on the subject of epituberculosis, states that the condition is a manifestation of post-primary tuberculosis in childhood which occurs when enlargement of the bronchial glands and a tendency to exudation exist. He regards atelectasis caused by bronchial blockage by tuberculous glands to be the main aetiological factor with alveolar engorgement and exudation and tuberculous allergy as secondary factors. These observations, and the nature of the recovery in many cases of primary infection, suggest that where the balance between defence and attack is about equal, a primary or secondary lesion produced by a small dosage of tubercle bacilli may be mainly inflammatory in character and is capable of complete resolution if the multiplication of the bacilli is held in check.

FAMILY AND PERSONAL HISTORY. Interrogation as to the family and personal history of an individual under examination frequently yields information which directs attention to the possibility of tuberculosis. A family history of tuberculosis may suggest an inherent predisposition to the disease, but the more significant inference to be drawn when the history reveals that there has been direct contact with affected members is that the individual has been exposed to infection. While due importance must be attached to a history of contact, an individual may be in contact with infected persons without developing clinical manifestations of tuberculosis or even a primary infection. The age of the individual should be noted in relationship to the type of the disease met with in the various age-groups. The occupations followed by the individual may indicate the existence of predisposing factors or the presence of added risk of infection as is the case in workers in silica dust, barmen, cowkeepers, and butchers.

The history as to previous health may yield information as to the onset of primary infection or of a subsequent clinical development of the disease. Febrile attacks and evidence of lymphatic

gland infection in childhood are frequently associated with primary infection. A history of chronic ill health in a child calls for thorough investigation. A history of haemoptysis, of pleurisy with effusion, and of previous disease of glands, bones, joints, skin, or other extra-pulmonary structures should suggest the possibility of an existing active infection.

SYMPTOMS OF CLINICAL TUBERCULOSIS. The classical symptoms of the pulmonary and extra-pulmonary forms of tuberculosis are well known. These vary according to the type of the disease and the severity of the infection. In active tuberculous lesions there always exists some indications of toxaemia which varies in degree and which if not pronounced may be overlooked. Fishberg has emphasized this point in relation to diagnosis and states that if there are no symptoms of constitutional toxaemia the patient may have been infected with tubercle bacilli but is not sick with a disease which needs special treatment. Toxaemia of the earlier and less active forms of tuberculosis may find expression in unobtrusive symptoms which may be overlooked. Marshall states that most of the symptoms in the earlier stages of the disease are those of toxaemia, although many of them are not specific. The early indications of toxaemia to which he draws attention are fatigue, loss of morning appetite, loss of weight, amenorrhoea in a young female, and evidence of neurasthenia or nervous breakdown.

The clinical symptoms of intoxication, namely, pyrexia, accelerated pulse, sweating, wasting, and loss of strength are well known and are usually associated with well-marked disease, but less obvious indications of toxaemia may be met with in the earlier phases of the disease. These indications arrange themselves into certain recognized groups. Lassitude and languor associated with a subnormal temperature constitute early evidence of toxaemia. Dyspeptic symptoms associated with anaemia and night sweating in young adults frequently arise from the toxic effect of an early lesion. In a young male anaemia is more frequently due to tuberculosis than to any other morbid condition. Muscular wasting associated with persistent headache and neurasthenic symptoms may be traced in many cases to toxaemia produced by the tubercle bacillus. Persistent pyrexia is the most frequent and most reliable indication of toxaemia, and no case

can be thoroughly investigated without careful records of the temperature range; a temperature which reacts to physical exercise is of special significance. A persistent subnormal temperature with increased range or amplitude is also met with in early stages of the disease.

To the experienced observer the appearance of the patient may suggest the presence of toxaemia, the appearance varying according to the extent and duration of the disease. In well-marked toxaemia the patient bears the stamp of illness. The so-called phthisical and scrofulous types of former days may be observed in certain cases. A toxic pallor with patchy pigmentation, crops of freckles against an unnaturally pale background, and malar flushing when not artificial are points to be noted.

The localizing indications of clinical tuberculosis vary according to the organ or structure involved. Cough, expectoration, and haemoptysis are well known as the cardinal symptoms of tuberculosis of the lungs. Cough is rarely absent although its existence may be denied by the patient. Sputum may be absent or it appears to be absent for the reason that it is swallowed; whenever sputum can be obtained it should be examined bacteriologically. Slight haemoptysis alone is a misleading symptom as it may be due to other causes, but an unexpected free haemoptysis to the extent of a cupful or more in an apparently healthy individual is, as Maxwell points out, a significant diagnostic symptom. Dyspnoea is a symptom of rapidly progressive and advanced disease. The typical dysphonia of laryngeal tuberculosis is well known, although alteration in the character of the voice may be due to other causes, but whatever the probable cause the condition of the larynx should be fully investigated.

In certain forms of extra-pulmonary tuberculosis pain is an early and significant symptom and, when the disease involves joints, limitation of movement is early observed; persistent pain is the most frequent indication of spinal tuberculosis; referred pain is sometimes present and may be misleading.

In the diagnosis of tuberculosis less importance is now attached to symptomatology, owing chiefly to the reliance which is placed on the diagnostic aids provided by radiology and other means. The writer recalls the early days of his tuberculosis experience when the diagnosis of pulmonary tuberculosis was determined

by a study of the symptoms, by stethoscopic examination, and by microscopical examination of smears prepared by himself, with the subcutaneous inoculation of tuberculin in doubtful cases; no radiological examinations or modern laboratory facilities were then available. It is unfortunate in some respects that the pendulum has swung so far in the direction of what one may term technical diagnosis, as in general practice the general practitioner must still place some reliance on the older methods, although he is fortunate in being able to call to his aid the services of experts and of modern diagnostic methods.

PHYSICAL SIGNS OF TUBERCULOSIS. It is not necessary to give any detailed description of the physical signs which are characteristic of the various types of tuberculosis; these are fully described in works dealing with the clinical aspects of the disease. It is necessary, however, to emphasize the importance of careful physical examination not only in relation to diagnosis, but in regard to the progressive character of the lesion and to the response which is being made to treatment. In general practice the medical practitioner, secure in the knowledge that he has available modern methods of diagnostic investigation, is liable to treat too lightly the necessity for the careful physical examination of a patient who has consulted him. But the knowledge gained from careful physical examination when viewed in the light of the subsequent information derived from radiological and bacteriological examinations is of real value in enabling the practitioner in general practice to have a more accurate conception of the incidence of tuberculous infection and to have a clearer appreciation of the variations in type which the disease presents.

RADIOLOGICAL EXAMINATION. The greatest advance which has been made in connexion with the diagnosis of tuberculosis within the last thirty years is in the field of radiology. No case of tuberculosis of lungs, bones, or joints can be accurately investigated without an X-ray picture of the structure involved. In the examination of contacts also, and in the wider investigation of selected groups of individuals, the employment of radiographical readings in association with tuberculin tests provide the most reliable means of detecting early indications of clinical infection in the absence of more positive findings. It is necessary, however, to make some allowance for possible error

in the interpretation of the radiographical picture, as the lesions of tuberculosis, more especially of acute type, may be closely simulated by other morbid conditions.

In doubtful cases of pulmonary disease and in conditions of chronic ill health in young adults radiological examination of the chest should never be omitted. Jessel recommends that pulmonary tuberculosis should be regarded as at least a possibility and skiagraphy should be employed in the following circumstances:

1. In cases provisionally diagnosed as bronchitis or 'bronchial catarrh' which do not clear up within four weeks.
2. Where patients complain of indigestion and dyspepsia. Many so-called 'gastric or duodenal ulcers' are really manifestations of tuberculous toxaemia.
3. In cases of alleged haemoptysis.
4. In young persons with symptoms of debility or anaemia.
5. In cases of chronic hoarseness.
6. In cases of ischio-rectal abscess.
7. In all cases where there is a clear history of tuberculosis in some member of the immediate family or household.
8. Where there is a history of some other close association with a case of pulmonary tuberculosis—for example, friend or workmate in office or factory.
9. Where a case of tuberculous meningitis or other form of non-pulmonary tuberculosis is found, attention should be directed to adult members of the household, even if stated to be in good health, in order to discover a possible source of infection.

In the early stages of pulmonary tuberculosis screening reveals evidence of apical involvement by the fact that the affected apex does not light up during inspiration to the same extent as the normal apex, and by limitation of movement of the diaphragm on the affected side. When the disease is more advanced the picture revealed by the radiographical film becomes more definite, displaying areas of density of variable degree which may be intersected with fibrous bands or have well-marked opaque spots. Mottling of coarse or fine character may be observed, the latter being an indication of active disease; a clear, well-defined area of an oval or circular shape is suggestive of cavity formation. Crocket states that active tuberculous disease of the lungs is indicated by the existence of shadows which present varying degrees of density with poorly defined fluffy margins which

surround them like a halo. He emphasizes the point that an X-ray examination should never be substituted for a careful clinical examination, and that it should be used for the purpose of amplifying clinical methods, not to supersede them.

Dorothy Dow and W. Lloyd in their third paper dealing with their investigations on the subject of tuberculosis in children give a description of the radiographical appearance of certain pathological conditions in children. The findings are of special value as a guide to radiological readings as they were interpreted by a sub-committee of the medical staff of Brompton Hospital, and a description is given on the opposite page.

Considerable advance has been made within recent years in securing more accurate and more clearly defined radiographical pictures of the lung by the use of the tomograph. Tomography has been defined as the sectioning of an organ or part of an organ by X-rays. Burrell had described the use of tomography as restricting the view to the lesion which it is necessary to radiograph and eliminating shadows which would otherwise be superimposed. McDougall, who has made a special study of the value of the tomograph in the elucidation of morbid conditions of the lungs, emphasizes the reliability of the information relating to pulmonary tuberculosis revealed by tomographic images. The extent to which surgery is now employed in the treatment of chest diseases has attached greater importance to the accurate localization of cavities and to the pathological nature of pulmonary lesions. McDougal points out that not only does investigation by means of the tomograph yield clearer information regarding the nature of a cavity wall and the tissues around it and its relationship to the bronchial tree, but it reveals the existence of distinct cavities which had not been detected by ordinary X-ray examination.

TUBERCULIN REACTIONS. A positive reaction to one of the tuberculin tests indicates that the individual in whom it has been obtained is allergic, that is, he has been infected with the bacillus of tubercle and his tissues have reacted with a varying degree of resistance to the toxic products of the organism. The reaction sheds no light on the character of the infection, which may have healed or be latent or progressive, while in long-standing cases with profound intoxication the reaction may be negative.

PATHOLOGICAL CONDITIONS	X-RAY APPEARANCES
A. *Abnormal Tracheo-Bronchial Glands.*	
1. Enlarged 2. Caseous	No abnormal shadows seen unless the glands sufficiently large to project beyond normal mediastinal shadow.
3. Calcified.	Shadows must be (*a*) sharp in outline, (*b*) of great density, and usually (*c*) irregular in shape.
B. *In the Lung Parenchyma.*	
1. *Infiltration*—An invasion of lung parenchyma by any abnormal tissue which alters its structure; the term is not, therefore, limited to infiltration due to tuberculosis.	Normal lung appearance is altered by presence of localized areas of diminished translucency, outlines of which are generally ill-defined.
1a. *Fibrosis*—Infiltration with fibrous tissue.	Evidence of infiltration is accompanied by definite homolateral visceral displacement.
2. *Healed Primary Focus* of tuberculous infection, as described by Ghon and Canti.	Small calcified focus in lung parenchyma, with or without calcification of corresponding tracheo-bronchial gland (for calcification, see above).
C. *Pleura.*	
1. *Pleural Effusion.*	Homogeneous shadow, usually with contralateral cardiac displacement, possibly showing definite margin.
2. *Thickened Pleura.*	This may appear as (*a*) homogeneous shadow, resembling that seen in pleural effusion, but without contralateral cardiac displacement; (*b*) obliteration of the costo-phrenic angle; or (*c*) peaking of diaphragm.

A positive reaction *per se* is of little assistance in arriving at a correct diagnosis of clinical manifestations of infection, but in conjunction with radiographical examination the tuberculin test is of definite value in determining, especially in children, whether a suspected lesion is likely to be tuberculous in character. A negative reaction may be accepted as postulating the absence of primary tuberculous infection, except in the type of case referred to above. From the point of view of prevention, importance has to be attached to a negative reaction as it connotes the absence of specific protection with the consequent existence of a greater degree of susceptibility in the absence of that unknown quantity inherent immunity.

The tuberculin tests which are in use or have been employed for the detection of infection with tubercle bacilli, include the subcutaneous test, the intracutaneous test of Mantoux, the cutaneous test of Pirquet, the ophthalmic test, and Moro's cutaneous test.

In the subcutaneous test an initial dose of 0·001 cc. or less of O.T. or other tuberculin is injected subcutaneously; if this fails to evoke a positive response, higher doses may be given, but it is inadvisable to exceed 0·1 cc. A positive reaction is shown by a rise of temperature and some degree of *malaise*, and where a lesion of the lung exists there is usually some focal reaction indicated by increased cough and sputum with perhaps streaky haemoptysis and more marked physical signs; such a focal reaction is of diagnostic significance. At the site of inoculation a local reaction may occur. This test used to be frequently employed, but though reliable it is not altogether free from risk, and as it is unsuitable for children it has been largely superseded by the intracutaneous method.

Mantoux's intracutaneous test is applied by injecting a solution of Old Tuberculin into the skin. When the reaction is positive an area of hyperaemia with some heat and swelling develops in twenty-four to forty-eight hours. The percentage of positive reactors to this test varies according to the dilution of tuberculin used. Dorothy Dow and Lloyd, who have investigated the value of this test in a large series of children under the age of fifteen, recommend the employment of three dilutions, namely, (*a*) 1 in 10,000, (*b*) 1 in 1,000, and (*c*) 1 in 100. The results they obtained by the employment of these various dilutions are briefly

as follows: a positive reaction was obtained with a dilution of 1 in 10,000 in 26·7 per cent, which figure was increased to 38·9 per cent and 43·1 per cent with dilutions of 1 in 1,000 and 1 in 100 respectively. If all the children in the series had been tested with 1 in 100 dilution the ratio of reactors would have been 46·1 per cent. These observers conclude from the results of their investigation that the Mantoux Test is more delicate and more accurate than the Pirquet Test, while the former has the advantage that a measured amount of tuberculin is used in each case.

In the cutaneous test of Pirquet the skin is cleansed with spirit or ether and one drop of a 25 to 50 per cent dilution of Old Tuberculin is placed on the skin which is scarified through the tuberculin. As a control the skin is scarified through a drop of diluting solution. A positive reaction shows itself in twenty-four hours as an erythema with some swelling which develops into a papule; occasionally some general reaction occurs. Various observers have investigated the possible correlation between the character of the reaction to various dilutions of tuberculin and the character and intensity of the tuberculous infection which exists. Opie and McPhedran investigated the character of the reaction in children in relation to clinical and radiographical findings and came to the conclusion that a severe reaction or a positive response to weak dilutions indicated a heightened risk of severe tuberculous infection. D'Arcy Hart has tested the view that a patient who reacts positively to weak solutions of tuberculin is more likely to be suffering from clinical tuberculosis than from sub-clinical infection, and submits graphical evidence in support of it.

As regards the reliability of this test Dorothy Dow and Lloyd, in their investigation referred to above, found that the figure of the positive results obtained corresponded approximately with that obtained by the intra-cutaneous method with a dilution of 1 in 10,000, and this, they point out, agrees with the findings regarding the two tests obtained by Happ and Casparis.

The ophthalmic test is applied by instilling one drop of a one per cent solution of Old Tuberculin into the conjunctiva. When the test is positive, congestion of the conjunctiva develops in four or five hours. This is a delicate test, but owing to the risk of serious eye injury which may follow its application it is now seldom used.

Moro's cutaneous test is applied by inunction with a paste composed of equal parts of Old Tuberculin and lanoline. A positive reaction is indicated by the development of a papular rash within twenty-four hours at the seat of inunction. A modification of this test is the tuberculin plaster test first described by Malmberg, in which the tuberculin ointment is applied under a plaster, a positive result showing a bright flush with confluent pin-head papules. A further modification is the Vollmer patch test in which the plaster is used with undiluted Old Tuberculin. Court has found this test to approach in reliability the Mantoux test.

EXAMINATION FOR TUBERCLE BACILLI. The differentiation between infection and clinical disease frequently presents a difficult problem. The only conclusive evidence of the presence of definite tuberculous lesions apart from that supplied by pathological examination is the presence of tubercle bacilli in sputum, pus, discharge, or other material. The organism may be present in such small numbers that they cannot be detected in film examinations, although their presence may be proved by cultural or biological methods. A prolonged and careful investigation may therefore be required before it is possible in a given case to state categorically whether clinical tuberculosis is or is not present.

The most frequent method employed for the detection of tubercle bacilli is the microscopical examination of films of the suspected material stained by the Ziehl-Nielsen method and it is the one primarily employed in the examination of sputum. To facilitate the detection of tubercle bacilli the sputum may be specially treated before the films are prepared. A detailed account of the methods employed for this purpose will be found in a recent publication issued by the Joint Tuberculosis Council. In the absence of sputum the presence of tubercle bacilli may be sought in the droplets obtained by the mirror test or by the examination of stomach washes or faeces.

In the mirror test introduced by Burton Wood, the laryngeal mirror is placed in position as for examination of the larynx, and the patient is asked to cough. The droplets which are deposited on the face of the mirror are transferred to a slide and a film is prepared and stained. Cohen and Wood give the following

results of 200 tests of the mirror method for the detection of tubercle bacilli applied to seventy-five patients. In sixty-one of these tests pus cells and occasionally elastic fibres were found in droplets obtained from patients who stated that they were unable to produce any sputum. In sixteen of these sixty-one tests the presence of tubercle bacilli was demonstrated, while tubercle bacilli were also shown to be present by this method in ten patients who at the same time had a negative sputum.

Gastric lavage and examination of the stomach contents also provide a method for the detection of tubercle bacilli and have proved of value in the examination of contacts. Dixon, who has extensively employed this method, gives the following results of the examination of 500 gastric washes obtained from children under the age of ten years: In thirty-eight of these or 7·6 per cent a positive result was obtained in three by smear examination and in thirty-five after inoculation into guinea-pigs. In a recent investigation Kayne and Hounslow using both inoculation and cultural methods obtained 35 per cent positive results in the examination of the gastric contents obtained from 114 patients. Even more striking results obtained by gastric lavage and guinea-pig inoculation are recorded by Ina Gourley in the case of fifty-nine children examined by her; of these, twenty-eight or 47·4 per cent gave a positive result, 86 per cent of which gave a history of contact.

These figures illustrate the value of this method of examination and they serve to emphasize the necessity for a careful and systematic investigation of contacts before it is possible to dogmatize as to their freedom from clinical manifestations of infection. The method is of special value in the examination of children, who invariably swallow sputum, which is usually small in amount, while the physical examination of children apart from radiographical findings yields little reliable evidence of disease in the majority of cases. It may generally be accepted when this method gaves a positive result that the tubercle bacilli come from swallowed sputum and that an open pulmonary lesion exists. It is possible, however, that the bacilli may emanate from other sources, and it would be interesting to know if, in the case of non-contact children, bacilli of the bovine type have been recovered by means of gastric lavage.

Tubercle bacilli may also be recovered from the faeces in

patients with pulmonary disease who swallow their sputum and in those who suffer from intestinal lesions.

The cultural method of detecting the presence of tubercle bacilli in sputum and other material may be employed when smear examination has failed. The latter method is extensively employed in routine work because it is convenient and gives a rapid result, but several negative smear results cannot be accepted as definitely precluding the possibility of clinical tuberculosis. Where any trace of doubt exists, the material should be examined by cultural or biological methods and, if necessary, by both. In applying the cultural method to sputum it is necessary to employ measures to kill off the contaminating or extraneous organisms which are present, and for this purpose various chemical agents are employed. Sulphuric acid in low concentration is the agent now generally used for this purpose. A variety of culture media exists from which to select one for inoculation; of these the best-known are media suggested by Griffith, Hohn, Petroff, Loewenstein, Cumming, and Jensen.

Several observers have recently investigated the cultural method of detecting the presence of tubercle bacilli and have checked their findings by guinea-pig inoculations. Edblad investigated the comparative value of guinea-pig inoculations with the findings obtained from culture on Loewenstein's and Hohn's media in seventy-eight cases, chiefly those of surgical tuberculosis. His results were as follows—culture on Loewenstein's medium, positive twenty-one cases, culture on Hohn's medium positive in thirty-four cases, and guinea-pig inoculations positive in twenty-eight cases; he concluded that the combination of these three tests provided most interesting and reliable information. Edwards *et al.* compared the results obtained in the examination of sputum by the concentrated smear method slightly modified, as recommended by Pottenger, with those obtained by the culture method, the medium adopted being a slight modification of that of Loewenstein's. Their results are shown in the table opposite.

Shrewsbury and Barson have also tested the value of the cultural examination of sputum for tubercle bacilli as compared with the direct smear method. They employed three media for their investigation, namely, Loewenstein's, Petroff's, and Petragnani's, and they found that for routine work Loewenstein's was the best.

avirulent or possibly dead. Of 224 specimens of urine five were found positive by both methods and seven were negative on smear examination but positive by the culture method. Of twenty-three specimens of cerebro-spinal fluid, tubercle bacilli were found in one by both methods, while in three the smear was negative and the culture method positive. Eighty-three samples of milk were examined, of which two gave a positive result by both methods and five were negative by smear but positive on culture examination. On the other hand, two specimens showed tubercle bacilli by smear examination but were negative on culture. Twenty-two specimens of faeces were examined, and two were found positive by both methods, all the other specimens being negative.

The conclusions arrived at by Green from his investigation are that the culture method is a practicable measure for the detection of tubercle bacilli, that the percentage of positive results is distinctly higher than that obtained by the direct smear method, and that while the inoculation test is generally more reliable, it is not invariably so.

Further evidence of the value of the cultural method in the detection of tubercle bacilli in pleural fluid is to be found in the report of the Pathological Department of King Edward VII Sanatorium, Midhurst. The examination of pleural effusions complicating artificial pneumothorax in the case of thirty-five patients gave the following results: smear positive, also culture positive eleven or 31·4 per cent; of the remaining twenty-four negatives, cultural examinations gave a positive result in twenty-one, so that in 91 per cent of the thirty-five cases the presence of tubercle bacilli in the pleural effusion was demonstrated. An interesting investigation by Beck as to the extent to which bacillaemia exists in experimental tuberculosis shows the value of the cultural method in the detection of tubercle bacilli present in blood. Using Lowenstein's technique, he obtained positive blood cultures in eleven out of thirty-six tuberculous animals.

The inoculation test may be accepted as the most reliable method of detecting tubercle bacilli in suspected material, although it involves longer time and increased cost. The guinea-pig inoculation is administered by the sub-cutaneous or intraperitoneal route according to the material employed. The test is

of special value in the examination of milk, material obtained by gastric lavage, cerebro-spinal fluid, and pleural fluid. The value of the test was demonstrated in a case which recently came under the writer's observation. The patient, who was a boy aged twelve years, developed an acute illness which presented features suggesting pneumonia and which was associated with some pleural effusion. The fluid which was sterile, gave a positive result for tubercle bacilli with the inoculation test. The test is more complicated when sputum is the material to be examined, owing to the presence of extraneous organisms which may prove pathogenic to the guinea-pig. The adoption of measures to destroy these contaminating organisms and the employment of the sub-cutaneous route for inoculation overcome this difficulty.

The consideration of the various methods employed for the detection of tubercle bacilli emphasizes the character of the investigation which may be called for before it is possible to state that clinical tuberculosis is or is not present. While it will not be practicable to carry out the more searching methods in all cases which show negative smear results, such methods are called for where there exist indications obtained from radiographical findings, symptoms, or physical signs, or other features, which provide strongly presumptive evidence in favour of the presence of clinical disease of a tuberculous character.

BLOOD TESTS. The possibility of specific blood reactions providing an aid to the diagnosis of tuberculosis has been explored. The complement fixation reaction when positive is of some value as indicating the presence of tuberculous infection, and when negative as pointing to the absence of such infection. It is usually positive in 85 to 90 per cent of cases with clinical evidence of infection. Alcock *et al.* in a series of cases obtained positive results in 90·6 per cent of patients with positive tubercle bacilli findings and only 36·5 per cent positive results in patients with negative findings. The rate of sedimentation of the red blood corpuscles in tuberculosis is now investigated as a routine measure; the rate is increased in active and progressive types of the disease. While this test alone provides little or no assistance in diagnosis, it is of definite value in prognosis.

DIAGNOSIS IN SUSPECTED PERSONS. Two separate types have to be considered in discussing the procedure

to be adopted in approaching the problem of diagnosis in suspected persons, namely contacts who must always be regarded as suspects, and individuals who, apart from the question of whether they are contacts or not, present evidence of some departure from a normal state of health.

The examination of contacts, especially of young contacts, to determine whether clinical infection is present or not provides a problem which calls for careful investigation. It is easy to determine whether a primary infection has occurred by the employment of the Mantoux Test, but to state whether there exists an unhealed tuberculous focus is much more difficult to decide. In the absence of confirmatory evidence provided by positive findings in sputum, stomach wash, or other material or by positive pathological findings in the tissue available in certain cases, e.g. enlarged lymphatic glands, a correct diagnosis can only be made from the reasoned study of the data supplied by several lines of investigation. Such data are obtained by physical examination, by investigation as to the presence and character of symptoms, more especially the evidence of toxaemia, by radiographical readings and by the response to tuberculin tests. The age of the child has to be taken into consideration in the examination of contacts, as children under the age of five years are more likely to present clinical manifestations of infection than children of school age. While due consideration must be given in the examination of contacts to the fact that the individual has been exposed to infection, this must not be allowed to influence one's judgment in favour of the positive diagnosis of tuberculosisunless evidence in favour of such a diagnosis is practically conclusive.

A difficult diagnostic problem is presented in the case of some children by the close similarity which exists between active pulmonary tuberculosis and non-tuberculous infections of the lungs, especially the condition to which Leys has given the name of chronic pulmonary catarrh. Young, who has directed attention to this condition in this country, states that measles and whooping cough are the most frequent aetiological factors, and that one or both parents frequently give a history of cough or chronic bronchitis. He gives the symptoms, which are fairly constant, as cough, sputum, which is frequently purulent, occasional haemoptysis, dyspnoea, and rise of temperature during the acute

phases. The chronicity of the condition, the intermittent character of the temperature excursions, the negative radiographical findings and the continued absence of tubercle bacilli from sputum or stomach wash proclaim the non-tuberculous character of this condition.

Considered judgment has to be exercised in the diagnosis of clinical tuberculosis of the bronchial glands in children. As the pulmonary tissue is the seat of primary infection in over 80 per cent of cases, it follows in accordance with Parrot's law that in a large percentage of tuberculin positive children there will have been an infection of the bronchial glands. On the other hand, in tuberculin negative children temporary enlargement of the bronchial glands may result from acute illness. Hamburger has drawn attention to the mistaken views which are held regarding bronchial gland tuberculosis. He emphasizes the fact that some involvement of the bronchial glands will have occurred in all individuals in whom aerogenous infection has taken place, but he deprecates the loose manner in which the term is applied to children, and he states that radiographical evidence of bronchial gland tuberculosis should be ignored unless supported by a positive tuberculin reaction, a high sedimentation rate, suggestive physical signs, and a radiological picture which shows something more than a mere hilar shadow.

Suspected persons who come up for examination because of symptoms suggestive of tuberculosis or for the reason that there exists or appears to exist some departure from normal health, frequently belong to one of the adult age-groups in which clinical tuberculosis most frequently occurs. In some of these cases the diagnosis is apparent and is readily confirmed; in others, a period of investigation is necessary before an accurate diagnosis can be made. To carry out such an investigation efficiently it is necessary that the individual should be admitted to the observation unit of a general hospital, a tuberculosis hospital, or a sanatorium. The investigation to be complete must include all the lines of inquiry which have previously been indicated and which are necessary for a full elucidation of the case. The character of the investigation will depend upon the organ or structure which is under suspicion, but the fact must never be overlooked that tuberculosis is a general infection and that extra-pulmonary

tuberculosis means in the majority of cases a primary pulmonary infection. The procedure adopted in the investigation of a suspected or doubtful case necessarily varies in different institutions, but when all available data have been secured it will be found that the best system to adopt is to submit the data for a final decision to a medical board which has been specially appointed for the purpose. This method has been in operation in the county of Hertford for a number of years, and it has answered well. It provides that no doubtful or suspected case is retained in the sanatorium for any extended period without being fully investigated. The Medical Board consists of the Medical Superintendent, the Chief Clinical Tuberculosis Officer, and one Tuberculosis Officer. The method adopted for the investigation and the findings of the Board are shown in the report form opposite.

The diagnosis of various forms of extra-pulmonary tuberculosis in the absence of positive evidence may also present considerable difficulty. In early cases of tuberculosis of bones and of joints with involvement of bony structure, radiographical readings by a recognized expert are essential to a correct diagnosis, and even then the diagnosis may be impossible until a later date, or if practicable, until a portion of the structure involved is obtained for pathological examination. Seddon has employed the method of examination of the inguinal lymph gland first described by José Valls as an aid to the diagnosis of tuberculous disease of the knee. He points out that tuberculosis of the inguinal lymph glands is known to occur in association with the following conditions: (1) generalized tuberculous adenitis, (2) tuberculous infection of the anal region or vulva, and (3) tuberculous infection of some part of the lower extremity. The technique which Seddon employs consists of the removal under local anaesthesia of one or, if easily accessible, of two inguinal lymph glands, portions of which are submitted to biological, cultural, and histological examination. In eighteen cases he obtained positive results in fifteen; of these thirteen were positive on sectional examination and seven were positive to the biological test, while in five cases positive results were obtained by both methods of examination. A similar method of diagnostic procedure can also be employed in doubtful cases of arthritis of other joints. The diagnosis of meningeal tuberculosis in young children in the

HERTFORDSHIRE COUNTY COUNCIL

COUNTY SANATORIUM, Ware Park

REPORT OF MEDICAL BOARD

Name of Patient .....
Address .....
Date admitted ..... Date boarded .....
Was patient admitted as Suspect? .....
If not, reason for boarding .....
Physical signs .....
.....

	At rest	After 5 mins. rest	After ... mins. rest	
Pulse				Temp .....

Weight ..... Standard Weight .....
Dates and results of X-ray examinations:
(*a*) Elsewhere .....
.....
(*b*) In Sanatorium .....
.....
Dates and results of sputum examinations:—
(*a*) Elsewhere .....
(*b*) In Sanatorium .....
Exercise reaction ..... BSR .....
Tuberculin reaction .....
Evidence of Constitutional disturbance .....
.....
Physical signs (diagram over page) .....
Decision of Board:—(1) Not tuberculosis.
(2) Latent tuberculosis of .....
(3) If Latent tuberculosis present is further observation (dispensary or domiciliary) or general supervision recommended .....
(4) Active tuberculosis of .....
(5) If active pulmonary tuberculosis: classification .....
.....
(6) If not tuberculosis state any other diseases present and treatment recommended .....
.....
.....
Remarks .....
.....
Signatures of Members of Board .....
.....
.....
Date .....

Note.—If any member of Board does not agree with findings, he should sign, but state reasons for non-agreement.

absence of confirmatory evidence from examination of the cerebro-spinal fluid presents a problem of special difficulty, as the meningeal symptoms may be caused by other pathological conditions. A history of close contact or evidence of a tuberculous focus elsewhere would favour the diagnosis of meningeal tuberculosis. Modern cystoscopic methods have rendered less difficult the early diagnosis of tuberculosis of the urinary system, while urine is always available for cultural or biological tests. Exploratory operations may be necessary before a correct diagnosis can be made in suspected cases of tuberculosis of structures or organs in the abdomen or pelvis, such as the peritoneum, the mesenteric glands, and the ovarian tubes.

Reference to such difficulties in connexion with diagnosis in certain types of extra-pulmonary tuberculosis emphasize the value of team-work and the need for the expert assistance of bacteriologist and pathologist, radiologist and surgeon, but in all such conditions the pulmonary condition should also be investigated, and the fact that tuberculosis is a general and not a local infection should never be overlooked.

GROUP INVESTIGATION. The ubiquitous and protean character of tuberculous infection in the human subject has led to the modern method of group investigation for the detection of clinical cases of the disease. The group selected may be one specially liable to infection, such as a small contact group or one in which, owing to age, occupation, or environment, the incidence of clinical tuberculosis is known to be higher than that in the general population or, again, the group selected may be representative of the general population living under urban or rural conditions. The chief method of examination employed in surveys of this character is by the interpretation of the radiographical pulmonary picture, and within recent years a number of such investigations have been carried out in different countries.

The following recommendations from a memorandum issued by the Joint Tuberculosis Council provide a helpful guide to the procedure to be adopted in the examination of contacts:

(1) The investigation of a contact case should be as thorough as that of any other tuberculosis suspect, and should include a radiographical examination.

(2) Certain contacts must be chosen by the tuberculosis officer for continuous supervision, especially (*a*) where more than one case of tuberculosis has occurred in the family; (*b*) where there is a continued infection in the home and (*c*) young children who show a high sensitivity to tuberculin.

(3) Though the attempt to examine all contacts at least once is to be encouraged if time permits, a careful investigation of selected contacts is more valuable than a perfunctory examination of a large number. The selection should include (*a*) any members of the family not in normal health, (*b*) all adolescents and young adults, (*c*) the consort of a husband or wife with tuberculosis, and (*d*) those who have been in close contact with an infectious case.

(4) Where there has been a death from tuberculous meningitis, or where one or more young adults have developed tuberculosis, the adult members of the family should be examined.

(5) Efforts should be made to secure the co-operation of the general medical practitioner and the school medical officer in the search for suspects.

(6) Use should be made of all opportunities for explaining to the general public the objects and benefits of contact examination.

(7) Contact examination should be regarded as providing an opportunity for clinical research on the factors predisposing to tuberculosis.

It is unnecessary to discuss further the results obtained by investigation of contact groups, as these have been given elsewhere, but reference may be made to the results obtained by some observers in the investigation of special and general groups, as the procedure is one of definite value in that it secures the detection of a number of cases at an early stage of onset and prevents the development of more serious tuberculous lesions.

The survey of a group of adolescents in urban and semi-urban working-class population between the ages of fourteen and twenty-one with a view to determine the incidence of latent pulmonary tuberculosis has been carried out by Wingfield and Macpherson. A total of 2,381 adolescents were submitted to radiological examination, of which 1,350 were pupils attending secondary schools in Surrey, and 1,031 were employed in factories and shops. Of the total number fifteen or 0·65 per cent showed definite evidence of tuberculous lesions, while in a further eighteen the films were abnormal, and in ten of these the shadows were accepted as being in all probability due to tuberculous lesions; this gave a possible incidence in the group of 1·08 per cent. The writers point out that their findings show a lower incidence of

latent tuberculosis than that obtained by other observers, and quote the following figures:—3·9 per cent among University students, by Hetherington *et al.*; 1·8 per cent by Soper and Wilson; 1·5 per cent by Steihm; 2 per cent among Munich students by Kattentidt; 4 to 5 per cent in Barcelona students by Saye; and the high figure of 17·9 per cent among young members of professional classes in China by Hall and Chang.

Misgeld, who refers to the fact that it is now possible to carry out routine radiological surveys in Germany, gives the results of the investigation of two groups. In one group composed of 868 persons, chiefly from rural districts, he found twenty persons with evidence of active tuberculosis, more than half of whom had a positive sputum. In a second group of 2,200 persons, who on clinical examination were considered to be free from infection, he obtained evidence of active tuberculosis by radiological examination in 0·4 per cent.

Considerable importance has been attached to group investigation in America as a means of detection of early tuberculous lesions and as a procedure of definite value in preventing the development of more serious manifestations of the disease, the chief groups selected comprising school children, college students, medical students, and nurses. Long, who gives a summary of the literature on the subject, refers to the findings of various observers in this field of investigation. He comments on the efficient method for the early detection of the disease in school-children adopted in the state of Massachusetts, and quotes the results obtained by Chadwick. The procedure which has been adopted in that state for at least a period of ten years includes: (1) the application of the tuberculin test, (2) the radiological examination of positive reactors, and (3) a clinical examination of pupils with positive radiographical findings. The following is a summary of the positive findings:

Number tested with tuberculin	400,591
Percentage of positive reactors	25·0
Number who had radiological examination	103,462
Number who had physical examination	117,777
Percentage of adult type disease in positive reactors	0·261
Percentage of childhood type disease in positive reactors	5·62
Percentage of suspects in number tested	3·08

The Importance of Early Detection

This survey shows that during the decennium 1924–34 there were discovered 261 cases of adult type disease, 5,620 cases of the childhood type, and 12,323 suspected cases, the great majority of which would have remained undetected in the absence of some such comprehensive scheme of investigation. The value of the scheme, if followed by the adoption of appropriate measures of prophylaxis and treatment for those in whom evidence of infection has been obtained, is that it provides protection against the recrudescence of latent lesions during the more susceptible periods of adolescence and adult life.

Somewhat similar investigations are carried out in America in connexion with the special groups of college students and medical students. According to Shepard fifty colleges have adopted a special scheme for the detection of tuberculosis among the pupils with routine yearly examinations. It is stated that each year among college students there is an average of six per thousand with evidence of the adult type of tuberculosis, and that in the country as a whole 30 per cent give a positive reaction to tuberculin. Long and Seibert give the following results obtained by them as to the ratio of positive reactors in college students in different geographical areas in America: Atlantic States, 46·6 per cent, Central States, 27·2 per cent; Mountain States, 45·5 per cent; and Pacific States, 39·5 per cent.

The incidence of clinical tuberculosis has been found to be relatively high in the medical-student group, and it is significant to note that the risk is greatest during third and fourth years of study. This increased risk is no doubt due to the confinement and strain associated with study, to under-feeding in certain cases, and to the greater risk of massive infection. The statistics given by Lees and quoted by Long show that in the University of Pennsylvania radiological examination revealed the following incidence of tuberculosis in various groups of students. Under-graduates, 0·6 per cent; freshmen, 0·3 per cent; law students, nil in 165; and medical students, 5·8 per cent.

The inferences to be drawn from group investigations carried out as described above are important and may direct attention to further developments in the field of prophylaxis. Long, in his communication already referred to, emphasizes the importance of detecting the presence of pulmonary tuberculosis at the stage

when the lesion is of a non-ulcerating lobular pneumonic character, as it is at this stage that suitable care and treatment will bring about resolution and complete cure. The carrying out of group investigations by means of tuberculin tests, radiological examination, and clinical examination, with the consequent preventive measures which must be adopted, necessarily involves expenditure of time, money, and labour, but in view of the accepted fact that in the majority of cases detection of a pulmonary lesion in the early pre-caseating stage is impossible by physical examination alone, the adoption of this system, especially in the case of groups exposed to risk such as contacts, is the only means by which the successful detection of early cases of clinical infection can be secured. Moreover, it provides for the subdivision of the group exposed to risk into three separate sub-groups; namely, susceptibles, those with primary non-clinical infection, and those with clinical infection. A knowledge of the existence of these groups is essential to the application of appropriate remedial and prophylactic measures.

FACILITIES FOR DIAGNOSIS. The provision of adequate facilities for confirming the diagnosis in doubtful cases of the disease must be available, more especially to the medical practitioner in general practice. The bacteriological examination of sputum, pus, and other suspected material, and the radiological examination of suspected lesions must be provided for as far as is practicable. While such facilities exist in the larger towns and cities and are readily available in connexion with clinics and at larger hospitals, they are only remotely available in scattered rural districts. It is not possible to provide facilities for radiological and bacteriological examinations in the rural districts to the same extent as is in urban districts, and it is here that the helpful co-operation of the general practitioner can be of real value. He can be regularly supplied with, and have always available the outfit necessary for the posting of specimens to the central laboratory, and he can notify the tuberculosis officer of the district that he wishes to have a specimen investigated or to have the suspected patient examined. The sending of specimens by post entails a certain amount of trouble and requires the intelligent co-operation of the patient, but it is time and trouble well spent. Too much emphasis cannot be laid on the importance of the

routine bacteriological examination of sputum and other material in the diagnosis of tuberculosis.

Radiological examinations present some difficulties in scattered rural districts, although these have been minimized during recent years by improvement in transport services. It is, however, difficult to provide X-ray facilities of a satisfactory standard of efficiency in many rural districts.

Chapter Seven

PREVENTION AND CONTRA-INFECTION

THE marked and progressive fall in the death-rate from tuberculosis which has been a feature of the last fifty years is evidence in support of the contention that the control and prevention of the disease is well within the compass of public health effort. The decline in the incidence of tuberculosis has been coincident with improvement in social and economic conditions. Improved housing and industrial conditions, better food, higher wages, and a clearer conception of the relation of cleanliness, fresh air, and sunlight to health have been instrumental in raising the standard of natural resistance to infection which has reinforced the influence of specific protection. There has also been a marked development in the measures adopted to minimize the risk of infection, while the institutional treatment of cases of the disease, the segregation of advanced cases, and the removal of contacts from infected homes have secured a lessened exposure to risk; consequently the output of tubercle bacilli has been greatly decreased, and the proportion of the population exposed to the danger of massive infection has been much reduced.

Some interesting and important aspects of the control of tuberculosis are presented by Frost. He postulates the possibility that some part of the decrease in the death-rate from tuberculosis may be due to a cycle change of the organism, but he considers that probably the most important factors responsible for the decline are selective mortality and the augmentation of non-specific resistance by improved environmental conditions. He considers that the frequency of exposure to actual infection is probably much less than would appear to be indicated by the high ratio of tuberculin positive individuals, and that present indications point to the gradual elimination of the tubercle bacillus as a pathogenic organism. He mentions two factors, however, as likely to reverse the process of elimination; namely, impairment of the standard of human resistance and some definite alteration in the adaptation of the bacillus to the host.

A study of the history of tuberculosis as it affects both man and the lower animals, and consideration of the various underlying factors which are responsible for the development and spread of the disease, indicate the lines along which further progress in the field of prevention and control must be made. Whatever views may be held regarding the causes and prevention of tuberculosis two main lines of advance to secure a further decrease in the incidence of the disease are indicated. On the one hand efforts must be continued to secure a higher measure of protective resistance and, if possible, complete immunity, while on the other, continued action must be taken to reduce to a minimum the risk of infection from existing cases of the disease.

NOTIFICATION. One of the first steps taken in the initial development of official schemes of prevention and treatment was to provide for the notification of tuberculosis by medical practitioners. The present system of notification would be of greater value if it were so amplified as to provide information regarding the type of the disease, the data on which the diagnosis has been based, and the status and home conditions of the patient. This would provide useful information to the authority, and it would give to the medical practitioner an added sense of responsibility and a greater appreciation of the importance of notification. Patients are now frequently referred directly to the tuberculosis clinic by the medical practitioner without being notified and without being examined. While this has definite advantages in relation to early diagnosis and treatment, it is unfortunate if it is responsible for the general practitioner losing touch with the clinical aspects of the disease. Something is lost in the scheme of things if the general practitioner regards it as unnecessary to make a careful clinical examination of patients because they are or may be tuberculous. By doing so he loses touch with, and interest in, the clinical features of the disease.

The duties of notification are imposed by the Public Health (Tuberculosis) Regulations, 1930. Article 5 provides that every medical practitioner and school medical officer shall notify the medical officer of health of the district within which the person resides, of a case of tuberculosis within forty-eight hours of seeing it, provided he has no reason to believe that the case has previously been notified. Under Article 6 it is the duty of the medical officers of public assistance institutions and

sanatoria to notify immediately after the end of each week particulars of cases of tuberculosis admitted to, and discharged from, the institutions during the preceding week. Article 7 deals with the diagnosis of tuberculosis which must not be based exclusively on the evidence of infection obtained from tuberculin tests. The duties of medical officers of health as defined in Article 10 relate to the receipt of notifications of tuberculosis and to the addition to, and removal from, the tuberculosis register of the names of notified persons. Each quarter the medical officer of health has to submit a statement giving particulars of the number of cases on the tuberculosis register, and of the additions to, and removals from, the register which have been made.

Recovery from tuberculosis is defined as the absence of symptoms, signs, or other evidence of existing disease for a period of five years in the case of respiratory tuberculosis and for a period of three years in the case of other forms of tuberculosis.

The notification of cases of tuberculosis to the medical officers of health of the districts in which the patients reside postulates the adoption of preventive measures. Article 11 of the Regulations requires the medical officer of health to make such inquiries and take such steps as are necessary to investigate the source of infection, to prevent the spread of infection, and to remove conditions favourable to infection. Article 12 deals with special powers and duties of local authorities in relation to the disease; these include the supply of medicine or other assistance, including articles which may be necessary for the detection and prevention of the disease and the provision and distribution of information and instruction regarding tuberculosis and the precautions to be taken to prevent the spread of infection. Article 13 specifies the circumstances under which notification is not required.

Additional duties devolve upon medical practitioners in regard to the notification of insured patients. As prescribed by the National Health Insurance (Medical Benefit) Regulations, 1936, the duties include (*a*) sending to the Tuberculosis Officer an initial report of a patient suffering from tuberculosis on Form G.P. 17 (Revised); referring a case of suspected tuberculosis to the Tuberculosis Officer for advice on Form G.P. 35 and (*c*) forwarding a record of the progress of a patient under domiciliary treatment on Form G.P. 36 at intervals not exceeding three months. The duties of medical practitioner in respect of patients also include sending information of any serious change in the condition of insured patients suffering from tuberculosis who are receiving treatment from him and information regarding any emergency treatment to a tuberculous patient who has not been recommended treatment under him. The medical practitioner has also to confer with the Tuberculosis Officer from time to time in regard to patients suffering from the disease.

SPECIAL PRECAUTIONS. Although tuberculosis cannot be regarded as belonging to the category of highly infectious diseases, certain precautions have to be adopted to minimize the risk of infection. Coughing, especially of the explosive type, is the main factor in the expulsion of infected droplets. The control of coughing and the use of a moist handkerchief to cover the nose and mouth during the acts of coughing, sneezing, or other forcible expiratory efforts are, therefore, necessary precautions to take. An individual suffering from open tuberculosis should never fondle or cough in the direction of a child, indeed, proximity to a child within a distance of three or four feet should as far as possible be avoided.

As the sputum is the chief medium for the expulsion of large numbers of tubercle bacilli its careful collection and destruction is an essential precaution. Individuals suffering from pulmonary tuberculosis, except in the advanced and closing stages of the disease, are able to exercise almost complete control over their sputum, and are consequently able to secure its destruction. To secure this it is necessary that the sputum should be expectorated into a sputum flask or sputum cup containing a small quantity of 5 per cent carbolic acid or a solution of dettol, izal, or other suitable antiseptic. Once or twice a day the sputum vessel should be emptied and sterilized or be washed out with antiseptic solution, the contents being incinerated, buried, or flushed down the water-closet drain. In tuberculosis institutions special sterilizers are provided for this purpose. If the sputum be of small amount it may be expectorated into a handkerchief made of cheap material provided this is placed in antiseptic solution or is destroyed by incineration. This method may be adopted by the ambulant tuberculous patient who is at work, and who may find it difficult to use the sputum flask; handkerchiefs used for this purpose should be kept moist with a weak antiseptic solution. In factories sputum receptacles containing antiseptic solution should be provided, and generally the habit of spitting in public should be prohibited.

In advanced cases of pulmonary tuberculosis when asthenia is marked and the expulsive powers of the patient are much impaired, soiling of the mouth, hands, bedclothes, and sputum receptacle with sputum is liable to occur. At this stage the

patient usually requires assistance to expel his sputum cleanly, and here the use of the cheap handkerchief or of swabs will be found helpful. The services of a nurse or of an intelligent relative at this stage is indispensable in securing the destruction of the sputum and the prevention of soiling.

A further source of origin of tubercle bacilli is the discharge from open cases of tuberculosis of bones, glands, and other structures. In advanced cases of tuberculosis of bones and joints there is frequently a considerable quantity of discharge which may soil the bedclothes and personal clothing if strict attention is not paid to the changing of dressings. In such cases it is necessary that suitable and sufficient material for dressings should be available, and that all soiled dressings should be destroyed by burning. When clothing is soiled by discharge it should be changed immediately and be sterilized or be soaked in or swabbed with antiseptic solution, according to the amount of soiling and the character of the clothing.

Precautions are also necessary with regard to cups, glasses, knives, forks, and spoons used by patients with advanced pulmonary tuberculosis. Each patient should have a marked set of such articles reserved for his own use; they should be washed in hot water and soda or be sterilized. There is direct evidence that infection can be conveyed by such articles, and it is a wise precaution to close every possible channel along which infection may be conveyed. The results obtained by various investigators have shown that pathogenic organisms may be recovered from imperfectly washed glasses, cups, forks, and spoons. Cumming has demonstrated that among troops the incidence of certain acute infections in which the causative organism is located in the nasopharynx is much lower when the mess-kit is washed up in especially hot water (76–100° C.). Cumming and Spruit have isolated various pathogenic organisms from the water in which utensils used by patients or carriers had been washed. The organisms identified and the percentage of positive findings of various material examined were: streptococcus haemolyticus, 84 per cent; pneumococci, 63 per cent; streptococcus viridans, 65 per cent; and tubercle bacilli, 35 per cent. These results indicate a two-fold risk; not only may the bacillus of tuberculosis be transmitted in this way, but the risk of inducing a more acute

type of mixed infection in individuals with latent pulmonary tuberculosis is increased. A precautionary measure, therefore, to which importance is attached is the proper cleansing with hot water and soda of such articles used by patients living at home, and the provision of facilities for sterilizing them in hospitals, residential schools, and other institutions.

The question of the terminal disinfection of rooms, bedclothes, and other articles is one regarding which there is no agreed consensus of opinion. The modern trend of medical opinion is that terminal disinfection, as generally practised, is of little value for the reason that the main methods of infection cannot be controlled by such means. In discussing this subject Paul states that terminal disinfection gives a false sense of security, and that it should be replaced by cleansing with soap and water, and further that tubercle bacilli are in no way inconvenienced by formalin or any other gaseous disinfectant. But whatever views may be held regarding the value or otherwise of terminal disinfection, there can exist no doubt as to the need for the thorough cleansing of a room occupied by a tuberculous patient, and in this connexion no risk should be incurred. Cleansing with soap and water, with the addition of a suitable antiseptic, the removal and destruction of all dust and litter, and the thorough ventilation of the room must be carried out. If some more direct method of disinfection is indicated the use of the antiseptic spray, followed by cleansing, will provide this.

In the public mind importance is still attached to gaseous disinfection of rooms and large buildings, including schools, but it is the least efficient and most difficult method of disinfection to adopt. The best method of disinfecting a room or classroom is to close windows and doors at night, after which no one should be permitted to enter the room. The following morning, the floors, woodwork, especially angles and corners, seats, desk, etc., are sprayed with an antiseptic solution in the composition of which dettol or formalin is specially effective. This is followed by thorough cleansing with soap and water and thorough ventilation by opening all windows and doors with the admission of as much direct sunlight as is available. Personal articles, including books which have been much used by the patient and are of no great value, are better destroyed.

INDUCTION OF IMMUNITY. The development and maintenance of resistance at a level which will protect the individual from tuberculosis is an essential preventive measure. The protection aimed at may be specific, or non-specific, or a combination of both. We are unable to envisage at the present time what actually underlies relative or complete non-specific protection, and this provides an obvious field for further investigation.

The possibility of inducing in infants a specific protection or immunity in the light of our knowledge regarding acquired relative protection has been explored by Calmette and Guérin, who employed for this purpose a special attenuated strain of bovine tubercle bacilli now well known as B.C.G. (Bacille Calmette-Guérin). This strain, owing to repeated sub-culture, is stated to be completely innocuous as regards pathogenicity, but to retain its antigenetic properties as the bacilli which enter into the composition of the culture are alive although attenuated.

While the method of immunization advocated by Calmette and Guérin is based on sound and accepted principles, it must fulfil certain conditions to be of any practical value as a preventive measure. The vaccine used for purposes of immunization must be innocuous and be incapable either immediately or remotely of assuming virulent properties and giving rise to tuberculous lesions which contain bacilli capable of further exaltation of virulence. The measure of immunity it confers must be uniform and reliable and should continue for a period of ten years and certainly for a period of not less than five years. Lastly, it should be capable of resuscitating protective resistance if and when this begins to wane. To what extent B.C.G. fulfils these conditions has been the subject of much investigation.

It is generally accepted by those who have investigated the character of B.C.G. that it is harmless to the human subject if prepared according to the directions of Calmette and Guérin. The tragedy of Lubeck in 1930 which resulted in seventy-three deaths following the oral administration of the vaccine was accepted by the court before which proceedings were instituted as due to laboratory contamination by a virulent strain. Irvine quotes the evidence of Kleinschmidt, L. Lange, and B. Lange which supported this conclusion. A second group of deaths in infants to whom B.C.G. had been administered occurred in

Hungary. These cases were investigated by Irvine, but the evidence he was able to obtain was insufficient to enable him to trace any relationship between the cause of death and the administration of the vaccine. Of twelve deaths which occurred, four were recognized as due to tuberculosis, three with pulmonary cavities, and one with pulmonary and meningeal tuberculosis. Of the remaining eight, the official causes of death were: acute respiratory diseases, four; meningitis, convulsions, marasmus, and measles, one respectively. One rather suspicious feature in the three infants who died from pulmonary tuberculosis with cavitation is the early age at which symptoms of infection were first recognized: namely, two months, three months, and five months respectively. Two of these cases gave a history of contact, and this may be the explanation of the infection, but the third case suggests no such cause. This infant was born in a lying-in hospital of a healthy mother, father unknown. After birth she was transferred to an infants' home, and at the age of two months commenced to lose weight; she was transferred to a children's hospital at the age of five months, and died two months later. While it is possible that infection occurred in this case in the infant's home, no evidence in support of this was forthcoming.

Isolated cases of deaths following B.C.G. administration to infants are also recorded, but the possibility of contact infection in a number of these cases cannot be excluded. On the other hand, B.C.G. has been administered to a large number of infants without any obvious deleterious effect, and in this connexion Irvine states 'that 1,343,000 have been given the vaccine and there is not yet one sure case of death from B.C.G. infection'. The cause of death, when it does occur after the administration of B.C.G., calls for further investigation. The influence of shock cannot be altogether ruled out, as has been proved by animal experimentation, and the possibility that the vaccine may prove an excitant to the development of encephalitis lethargica is not to be overlooked. According to Bocchini a number of infants who have received B.C.G. die from tuberculous meningitis during the first few weeks of life.

That B.C.G. vaccine is capable of assuming virulent properties and of producing progressive tuberculous lesions in guinea-pigs has been proved by various observers, but the greater susceptibility

of the guinea-pig to bovine tubercle bacilli has to be borne in mind in this connexion. Stanley Griffith has shown that guinea-pigs may succumb to shock when given large doses of the vaccine. Watson *et al.* investigated the effect of inoculation with B.C.G. in guinea-pigs and found evidence of the development of tuberculous lesions in 9 per cent of the animals inoculated. Somewhat similar results have been obtained by a number of other observers, and exaltation of virulence has also been obtained by passage through animals. On the other hand, many observers have failed to produce progressive tuberculous lesions in animals by inoculation with B.C.G. vaccine or to obtain any increased virulence by animal passage. These somewhat conflicting results postulate either variation in the standard of the vaccine used or an absence of uniformity in the methods employed in the experimental work. To secure the specific protection aimed at, the employment of a vaccine composed of live avirulent bacilli is probably essential, but if under any conditions they assume either immediately or remotely virulent properties the end aimed at is defeated.

The cultural and pathogenic properties of the various strains of organism of which B.C.G. is composed have been the subject of extensive laboratory investigation. Petroff has shown that the vaccine consists of two strains of organism, one presenting a rough surface on growth on appropriate medium which is designated *R*, and the other presenting a smooth surface which is designated *S*. The strain *R* was found to be innocuous, but the strain *S* was found to be pathogenic to guinea-pigs. The results obtained by Petroff have been confirmed by Dreyer and Vollum, B. Lange, and other observers. Calmette and other workers in this field of investigation have, however, failed to substantiate these results, namely, a resumption of virulence by altered cultural conditions. Recently Feldman has published the results of a prolonged investigation on the effect of the cultivation of a strain of B.C.G. on glycerinated egg medium; he obtained no increase in its virulence.

The extent to which the administration of B.C.G. vaccine is capable of producing some lasting degree of specific protection against tuberculous infection is still uncertain. That it is capable of producing a positive tuberculin response in a considerable

percentage of cases may be accepted as proved, and this would postulate a heightened resistance against the development of clinical tuberculosis. This protection, however, is probably only temporary in character, as after a period of twelve months the positive tuberculin response gradually fades and the position of the child as regards his defensive mechanism is as before, unless a further dose of B.C.G. is administered. It is not clear whether after this responsive phase has passed the infant still retains some measure of protection or runs a risk of increased susceptibility in later years.

The results which have been recorded by many workers abroad in this field of immunology support the view that the administration of B.C.G. to infants evokes a definite immunizing response, although it is difficult to compute the full value of the results obtained in view of many outside factors which influence them. The most recent figures relating to B.C.G. administration are those of Naesland and Tornblom. They give the results of the administration of the vaccine to 7,765 children born in the Swedish province of Norrbotten between 1927 and 1933. Up to the end of the year 1933 the general mortality among children who received B.C.G. was 4·1 per cent, whereas among control children it was 8·8 per cent. The death-rate from tuberculosis equalled 0·1 per cent in the case of children receiving B.C.G. compared with 0·5 per cent in the case of controls. No ill-effects following the administration of B.C.G. were observed. The authors state that they are unable to decide whether the good results they obtained are due to specific protection induced by B.C.G. or to other factors at present unknown.

The conclusions to be drawn from a study of the method of inducing immunity advocated by Calmette are fairly obvious. In the light of Koch's phenomenon and of our knowledge regarding the relationship of primary to secondary infection, the method is based on sound principles. Whether the bovine type of bacillus should be selected as the basis of an immunizing vaccine in preference to the human type is, however, open to discussion. That the B.C.G. vaccine is incapable of producing immediately or remotely progressive tuberculous lesions under any conditions has yet to be conclusively demonstrated. It has been shown that B.C.G. vaccine does evoke an immunizing response, but as this response is of relatively short duration it is

essential that the ultimate effect of the vaccine on resistance to clinical manifestations of infection should be known, and this can only be determined by following up the after-history of those to whom the vaccine has been administered. What is the effect of B.C.G. therapy in early life on the incidence of the disease in the young adult age-group and in middle life? A further point to be cleared up is whether the administration of a vaccine containing live tubercle bacilli is capable of evoking permanent immunity without producing a definite tuberculous lesion however small and innocuous.

Interesting immunizing results have been obtained by Hensel with dead tubercle bacilli. Twenty-one animals were inoculated with 0·005 gramme of tubercle bacilli suspended in 1 ccm. of lanolin, the organisms having previously been killed by exposure for two hours to a temperature of 65° C. These animals were subsequently inoculated intra-cutaneously with 0·00001 mg. of living tubercle bacilli and a similar inoculation was given to ten control animals: all the animals were killed three months later. In the control animals infection was found in the focal lymphatic glands, and in nine the spleen was involved. In the group inoculated with dead tubercle bacilli, with one exception no evidence of tuberculosis of glands or spleen was discovered. The main point to be noted in this interesting experiment is that the tubercle bacilli were introduced intra-cutaneously.

INCREASING NATURAL RESISTANCE. Apart from specific resistance, protection against clinical manifestations of tuberculous infection depends upon inheritance, which is an unknown factor, and that general resistive quality of the human body which is related to the standard of physical tone and nutrition in the widest acceptance of that term. These three factors may be envisaged as operating separately or as being supplementary to each other. The complete healing of a primary focus is to be regarded as resulting from inherent defensive and reparative processes which are influenced by the standard of nutrition and by an immunizing response evoked by the presence of the toxic products of the organism. Every factor which directly or indirectly improves the general standard of nutrition will strengthen the resistive capacity of the body against clinical infection with tubercle bacilli.

The fall in the death-rate from tuberculosis is not due exclusively to efforts specially directed against the disease. Improved housing, a higher standard of living as regards food and hygienic habits, maternity and child-welfare schemes, the school medical service, and other social services have all contributed their part in improving health and the capacity for resistance of the population.

The adequate intake of the essential constituents of food is a *sine qua non* to a satisfactory standard of nutrition. The foundations of future health are laid down *in utero* during the months of foetal life. The growth and standard of development of the infant during pre-natal life depends upon the health, vigour, and nutrition of the expectant mother, and these depend upon food, habits, environmental conditions, and other factors. Much attention is now given under maternity- and child-welfare schemes to the care and supervision of the expectant mother, and such care and supervision react beneficially on the growth and vigour of the unborn child and upon its future resistance to disease.

The correlation between health supervision during the ante-natal period and the condition and progress of the infant during the first twelve months of life has been investigated by Agnes Nicoll. The results obtained by her indicate that the taking of accessory nutrient substances such as milk, adexolin, ovaltine, etc., and the administration of preparations of iron or calcium during the pre-natal period were of advantage to the health and development of the child during the first year of life. The importance of an adequate intake of vitamins A, C, and D during the pre-natal and lactation periods have been proved by various investigators in this country and abroad, and it has been shown that the requirements of expectant and nursing mothers for these vitamins are much higher than is the case in women who are not concerned with the function of reproduction.

Infant welfare work has also exercised its influence in raising the resistive capacity of the young to tuberculosis. The establishment of exclusive breast-feeding and the conservation of the mother's health and capacity for lactation are of importance in securing a sound basis of health and resistance in the infant, while the risk of infection during the early months of life with the bovine type of bacillus is eliminated. The actual properties of the mother's milk which impart increased protection to the

infants are not clear. That Nature has provided that it should contain anti-bodies or other protective constituents is known, and that the degree of protection which the mother is capable of imparting to her infant will depend upon the state of her health and physical condition may be accepted. Evidence exists that the breast-fed infant possesses greater resistance to disease and greater powers of recuperation than the infant who is artificially fed. The results obtained in the investigations carried out by Agnes Nicoll, which is referred to above, emphasize the value of breast-feeding, as is shown by the following figures extracted from her paper.

Extent of breast-feeding	Health Standard of Infant		
	Highest	Inter-mediate	Lowest
Exclusively for 8–9 months or longer	44 (32·6%)	68 (48·9%)	27 (19·4%)
Exclusively or partially for 8–9 months or longer	52 (28·7%)	88 (48·7%)	41 (22·6%)
Discontinued before the end of third month	15 (17·4%)	38 (44·1%)	33 (38·3%)
Never established or given up before end of first month	5 (19·2%)	9 (34·6%)	12 (46·1%)

The conserving of the mother's health during the period of lactation is of importance in relation to the vigour and resistance of the infant. The removal of the mother and infant during the early weeks of lactation to a convalescent home is of proved value to the health of the mother, and greatly benefits the child. It provides for the mother rest, regular and adequate feeding, and a measure of freedom from domestic cares and responsibilities, which are speedily reflected in improved health and lactation. Such improvement is especially noted in the pale exhausted woman who comes from a poor home and who has suffered from shock and haemorrhage. Frequent pregnancy and lactation are responsible for impairing the resistance of the mother, hence

the value of post-natal care, convalescent rest, and the increased intake of special articles of food during the lactation period.

The care of infants and young children below school age which is provided for under child-welfare schemes is an important factor in improving the standard of health and resistance at this age. Of special value is the advice given in regard to feeding and the ancillary articles of food or special vitamin containing preparations which are prescribed with a view to improving nutrition. In this connexion milk and cod-liver oil preparations play an important part. The older physicians adhered to a sound principle when they advocated goats' milk, cod-liver oil, and chemical food for delicate children. The convalescent home also plays an important role in improving the health of young children suffering from impaired nutrition or whose resistance has been weakened by serious illness.

During school life the child comes under the aegis of the school medical service and the influences aiming at physical improvement which are now exercised by Education Authorities. At this age the child is less liable to develop pulmonary manifestations of tuberculous infection, as a high percentage of school-children has passed the test of primary infection without clinical disturbance and is possessed of a considerable measure of specific protection. It is desirable, however, that continued effort at maintaining nutritional resistance at a high level should be made in view of the critical age of puberty which lies ahead. The nutrition of school-children has been improved by the arrangements which now exist for the provision of milk at the small cost of one half-penny per one-third of a pint, or free of cost in necessitous cases. In distressed areas the provision of free meals has also been of special value in arresting the development of serious malnutrition. By such means assistance is given in maintaining the nutritional resistance which augments specific resistance at a level sufficient to prevent the development of clinical outcrops of infection, although in certain cases it is unable to do so.

Of the measures which aim at the prevention of clinical manifestations of tuberculosis primary attention must be given to adequate and balanced feeding, especially during the years of growth and development. The importance attached to the subject of diet and nutrition in relation to resistance is shown by

the following extracts from the First Report of the Advisory Committee on Nutrition:

'It is well known that deficiency of suitable protein or of any one of the essential mineral elements or vitamins results in a disorganized state of nutrition.'

'We believe that better physique and health can be obtained and resistance to disease increased by the application to human diets of recent knowledge which demonstrates the importance of certain classes of food for proper nutrition.'

'From the health standpoint there is no other single measure which would do more to improve the health, development, and resistance to disease of the rising generation than a largely increased consumption of safe milk by mothers, children, and adolescents.'

The following slightly modified tables which contain the basis of a correct dietary for mothers and children are taken from Appendix III of the Report:

Diet Table for Pregnant and Nursing Women

Protective Foods	Amount (grammes)	Calories
Milk	1,000	660
Meat, fish, or poultry	120	240
Eggs	50	70
Cheese	30	125
Green and leafy vegetables	100	30
Potatoes	250	250
Legumes, dried	10	35
Cod-liver oil	3·5	30
Raw fruit and vegetables (vitamin C). Suitable amount.		

Energy-producing Foods	Amount	Calories
White flour *or*	250	1,000
Whole-meal flour	250	1,000
Fats (preferably butter) and sugar	as required	as required

Basic Dietaries for Children at Different Ages

Protective Foods	Ages 1–2 years (840 calories)		Ages 2–3 years (1,000 calories)	
	Amount (grammes)	Calories	Amount (grammes)	Calories
Milk	750	490	1,000	660
One egg (or meat, fish, or liver)	48	70	48	70
Green leaf vegetables	30–60	15	30–60	15
Potato (or carrot)	30	30	50	50
Cod-liver oil	3	30	3	30
Energy-yielding Foods				
Fats (butter)	7	50	10	75
Cereals (bread)	50	150	50	150
Raw vegetable or fruit (vitamin C)	—	—	—	—

Protective Foods	Age, 3–5 years (1,200–1,300 calories)	
	Amounts (grammes)	Calories
Milk	1,000	660
One egg (or meat, fish, or liver)	48	70
Green leafy vegetables	60–100	20
Potato (and other root vegetables)	100	100
Cod-liver oil	3	30
Raw vegetable or fruit (Vitamin C)	—	—
Energy-yielding Foods		
Fat (butter, if possible)	15	110
Cereals (bread)	75	225

Protective Foods	Age, 5–7 years (1,400 calories)		Age, 12–14 years (boys 3,200 calories, girls 2,600 calories)	
	Amount (grammes)	Calories	Amount (grammes)	Calories
Milk	1,000	660	1,000	660
Egg	48	70	48	70
Meat, fish, liver, or cheese	30	40	90	120
Green leafy vegetables	100	30	250	75
Potato (and other root vegetables)	150	150	300	300
Cod-liver oil	3	30	3	30
Raw vegetable or fruit (vitamin C)	—	—	—	—
Energy-yielding Foods				
Fats (butter, if possible)	20	150	as required	as required
Cereals (bread, etc.)	100	300	as required	as required

The Commission in its report draws attention to certain points of importance in regard to the protective feeding of expectant and nursing mothers and young children so as to secure optimum nutrition with its corollary of a high standard of resistance. Stress is laid upon the necessity of a diet for expectant and nursing mothers which contains adequate amounts of vitamins and of calcium, phosphorus, and iron. The importance of iron salts in relation to the normal nutrition of young infants, and the fact that milk is deficient in iron is referred to, and the addition to the diet of all infants of foods rich in iron, such as egg-yolk and *purées* of green vegetables or carrots, is recommended. The need of an adequate intake for infants and young children of vitamins C and D, the latter especially, during the winter months when sunshine is at its minimum is now generally recognized; these are supplied by fresh fruit and vegetable-juice, and by the administration of three to six grammes of cod-liver oil.

The standard of nutrition at the age of puberty and in early adolescence, especially in females, calls for careful attention.

There exists evidence, part of which has come under the writer's personal notice, that young females for aesthetic reasons are given to the restriction of fat-containing foods, including butter. When to this are added the physical changes associated with sex-development and the fatigue inevitably associated with the stress and strain of modern life, the necessity of maintaining nutrition and resistance at a high level during the decade following puberty cannot be too strongly emphasized. The intake of foods rich in vitamins A and D at this stage of life must be encouraged.

The actual amount of food which is necessary to provide and to maintain a state of nutrition commensurate with resistance has to be considered in relation to certain factors which include work, environmental conditions, and individual characteristics. Crowden has estimated the approximate minimum cost of diets which are physiologically adequate based on the Cathcart scale of family coefficients as shown in the following table:

	Carbo-hydrates	Protein	Fat	Calories per man-value per day
Proportion per day per man-value . .	500·8 g.	108·4 g.	114·9 g.	3,570
Percentage calories .	58	12	30	—

Total cost for family per week, January 1932 { 25·3 } = { 1·02 per man-value per day / 7·2 per man-value per week }

In a Memorandum issued by the Ministry of Health reference is made to the necessary action to be taken to secure improvement in diet as regards amounts and essential constituents. To be satisfactory the diet must yield 3,000 to 3,400 calories per day, contain the proper proportion of animal protein, of fats, and of carbohydrates, an adequate amount of vitamins A, B, C, and D, and a sufficient supply of mineral constituents of which calcium, phosphorus, iron, and iodine are the most important. As pointed out in the memorandum, the best source of supply of the various vitamins are to be found in milk and milk products, fish

(especially fat fish and fish-roes), liver, eggs, fresh fruit, and fresh vegetables.

The consideration of the question of nutrition and food in relation to natural resistance to tuberculosis emphasizes the necessity for the adequate intake of certain constituents. Of these the most important are animal proteins, fats, vitamins A and D, and calcium and iron.

For the accurate assessment of the state of nutrition no practical and reliable scientific method has yet been evolved, while it is impossible in the present state of our knowledge to estimate the degree and character of the resistance to tuberculosis governed by nutrition. The state of nutrition depends upon the controlling influence of the nervous system, the powers of assimilation, the condition of the blood, and the response of the tissues to the intake of food. There are, however, other factors which adversely influence nutrition. Mental worry, too little sleep, fatigue, inherited proclivities, and the restriction of sunlight and moving air are responsible for impaired nutrition. Wilkins, who has made a special study of the assessment of the nutrition of school-children, points out that the recent nutritional state is shown chiefly in the soft tissues and the blood. As a guide to the standard of nutrition, he attaches importance to the proportion of flesh, fat, and muscle, the quality of muscle as indicated partly by posture, the texture of the skin, colour as expressing the character of the blood, and the general state of well-being.

A very complete investigation as to the condition of nutrition in 3,384 children of school age in Australia has been carried out by Clements. The tests applied were both physical and clinical and were of a comprehensive character and included the application of Pirquet's 'sacratama'. The children in the sub-normal group, and also a number in the normal group of nutritional development, were submitted to one or all of the following clinical tests: (*a*) an X-ray examination of the epiphysis at the wrist; (*b*) an estimation of the haemoglobin; (*c*) Gothlin's capillary resistance test for scurvy and border-line scurvy; and (*d*) a visual acuity test for night-blindness. As a result of the application of these physical and clinical tests Clements found evidence of unsatisfactory nutrition in 18·8 per cent of children in Western Queensland, in 13·3 per cent of children in the

North-western District of Victoria, and in 23·7 per cent of children in New South Wales. This investigation emphasizes the importance of a uniform and comprehensive method of assessing the nutritional standard of children, and of the necessity of increasing the consumption of protective foods to improve the nutrition of children and to increase resistance to disease.

Previous reference has been made to the character of the blood as an important factor in governing the standard of nutrition and the degree of resistance to tuberculosis. We know little of the real explanation of inherent resistance, but one is compelled to assume that it is upon the character of the blood that the resistive capacity of the tissues mainly depends, and that in time investigation will reveal the existence of some special characteristics of the blood as being responsible for extreme susceptibility on the one hand or a high degree of resistance on the other.

In considering the question of improved resistance to tuberculosis due regard must be paid to domiciliary and environmental conditions, which either beneficially or adversely affect nutrition. Domiciliary and personal cleanliness, suitable exercise, adequate sleep, exposure to fresh air and sunlight, and improved hygienic standards in the home, school, factory, and workshop, all exercise an influence in preventing impaired nutrition and diminished resistance to the disease.

INDUSTRIAL PRECAUTIONS. As the general health and the degree of resistance to tuberculosis of the wage earner are influenced by industrial conditions, it is necessary to carry out special precautionary measures in the factory, workshop, and other places of employment. The improvement in the hygienic conditions under which employment is now followed, as a result of the provisions of various enactments now consolidated in the Factories Act, 1937, has played a part in the reduction of the incidence of tuberculosis. Special attention is directed to cleanliness, suppression of dust, adequate lighting and ventilation, the avoidance of overcrowding and the prevention of undue fatigue. An important consideration is an adequate midday meal, especially in the case of young females who are doing fairly strenuous work. The provision of canteen arrangements which provide for a good meal at reasonable cost is an added welfare measure of value.

Section 1 of the Factories Act, 1937, provides that every factory shall be kept in a clean state and free from effluvia. Section 2 prohibits the overcrowding of factories to such an extent as to cause risk of injury to the health of the persons employed therein. With certain specified exceptions a factory is deemed to be overcrowded if the amount of cubic space per person is less than four hundred cubic feet. The exceptions are when for special reasons the Chief Inspector grants a certificate exempting the workroom from the provisions of the subsection, and as provided by subsection 3, in respect of any room used as a workroom at the date of the passing of the Act, the cubic space permitted shall be two hundred and fifty cubic feet for a period of ten years subject to the provision of effective and suitable mechanical ventilation before the first period of five years is completed. This subsection shall cease to apply to any room if it passes into the occupation of any other person or if default is made in the said provision of mechanical ventilation, or if effective mechanical ventilation ceased to be maintained. Section 3 deals with the temperature of workrooms and requires the maintaining of a reasonable temperature in each workroom. Where a substantial proportion of the work is done sitting a temperature of not less than sixty degrees shall be maintained and a thermometer shall be provided for each workroom. Section 4 makes it obligatory to provide and maintain adequate ventilation by the circulation of fresh air in each workroom and to render harmless all fumes, dust, and other impurities likely to be injurious to health. Section 5 requires effective arrangements for securing and maintaining sufficient and suitable lighting whether natural or artificial. Section 7 provides that efficient and suitable sanitary conveniences shall be available with proper separate accommodation for persons of each sex.

The Secretary of State may make regulations regarding the class or description of a factory or parts thereof and in regard to the heating, ventilation, lighting, and sanitary arrangements provided for factories or any class or description of factory.

Section 41 of the Act requires the provision of an adequate supply of wholesome drinking water. Section 53 provides that no work shall be carried on in any underground room. Sections 110 and 111 deal with home-work and the employment of persons in premises injurious or dangerous to health. Section 123 relates to the powers of inspectors and provides, *inter alia*, that an inspector who is a duly qualified medical practitioner shall carry out such medical examinations as may be necessary for the purposes of his duties under the Act.

In certain industries, reference to which has previously been made, which are associated with the liberation of fine silica dust,

special precautions have to be carried out. Section 4 of the Workmen's Compensation (Silicosis and Asbestosis) Act, 1930, prohibits an employer from employing in any industry involving exposure to silica or asbestos dust any workman who has been suspended under the scheme or has refused to submit himself for examination. In grinding, the Grinding of Cutlery and Edge Tools Regulations, 1925, recommend, *inter alia*, the following precautionary measures: the provision of hood and duct with localized exhaust draughts to remove dust during the process, the provision of general exhaust and inlet ventilation, wet grinding and an adequate supply of water; the construction, size, lighting, drainage and cleanliness of rooms to conform to conditions laid down in regulations and, lastly, the prohibition of spitting. The Refractory Material Regulations, 1931, provide for certain precautions in these industries in which dust is produced in all processes of breaking, crushing, and grinding. The breaking of refractory material by hand should be undertaken in the open air. The crushing and grinding of material in a machine must be carried out with an efficient exhaust draught or with an adequate supply of water or a steam spray. The escape of dust must be prevented by an exhaust draught or by means of protective covering. In the case of certain workers specially exposed to dust, respirators must be worn.

The Pottery (Silicosis) Regulations, 1932, require that provision be made for efficient exhaust ventilation or for the control of dust by water or steam spray.

In stone dressing, a dust-trapping apparatus connected to an exhaust draught is now available. Sandblasting is an occupation which gives rise to special risk. To prevent the escape of dust the glass is placed in a special protective chamber from which the dust is extracted by mechanical suction. Closely fitting respirators are also worn, and as an added precaution men are given one pint of milk per day.

Special precautions are also necessary for workers in asbestos; these include the employment of wet methods, the enclosure of dust-producing machines, exhaust ventilation and the avoidance of hand work involving contact with dust.

An important precautionary measure to take in connexion with workers employed in industries associated with silica dust is

initial medical examination, followed by periodic medical examinations. The extreme risk of group infection amongst workers in such industries makes it imperative that they should be protected from any possible contact with open cases of tuberculosis.

The arrangements for such medical examination are provided for by the Silicosis and Asbestosis (Medical Arrangements) Scheme, 1931, and the Amendment Scheme, 1934. Para. 3 of the 1931 scheme provides for the appointment by the Secretary of State of a Medical Board for the purpose of making medical examinations and reports and giving necessary medical certificates. Paras. 7 to 11 deal with applications relating to compensation arising in the case of death or disability. Para. 12 of the main scheme is amended by Para. 1 of the Amendment Scheme. This paragraph provides that a workman who is engaged for employment in any industry included in the First Schedule to the scheme shall submit himself for examination by a member of the Medical Board or other specially appointed medical practitioner before the end of the second month of such new employment or for such longer period as the Medical Board may authorize unless (1) being twenty-one years or more he has been employed in that industry or process or other process included in the schedule in the same industry at any time within the three years previous to such engagement or is being transferred from work in any industry or process which though not included in the schedule is included in a Compensation Scheme, or (2) being a workman under twenty-one years of age he has previously submitted himself for examination under this scheme and has satisfied the following requirements with respect to physique:—(1) The chest must be at least of average development and the respiratory passages must be free from obstruction. (2) There must be no signs of disease of the lungs or heart; and (3) There must be no tuberculosis of any region.

If on such examination mentioned above, the workman is found to be suffering from the disease (silicosis or asbestosis) or from tuberculosis of the lungs or, if not having been previously employed in any industry or process included in the schedule or not having been medically examined under the scheme or any compensation scheme, he is found on examination not to satisfy the requirements as to physique set out above, the case shall be referred to the Medical Board, who if satisfied, shall suspend the workman from further employment in the industry or process.

Initial and periodic medical examinations provide an important

preventive measure in those dangerous industries which are associated with inorganic dust, and they might with advantage be employed in connexion with other industries.

SEGREGATION OF OPEN CASES. The segregation of open cases of the disease in suitable institutions is a preventive measure of first importance. Patients who have tubercle bacilli in their sputum should not be permitted to remain at home if there are young children in the home, and unless isolation and adequate protective measures can be carried out. Coutts attaches primary importance to the following two precautionary measures, namely, to determine in every case of tuberculosis whether there exists an unrecognized case of the disease in the household, and secondly, to ensure adequate separation of the infected case from the healthy. While segregation is accepted as one of the main principles of preventive action, there exist difficulties in its general practical application. The prolonged duration of the advanced stage in many cases makes the question of adequate accommodation a problem of considerable magnitude and one which differs entirely from the provision required for patients suffering from acute specific diseases which are of relatively short duration. There are also patients with chronic disease who continue for years to expel tubercle bacilli and who, owing to the slowly progressive character of the disease, retain considerable ambulatory power for a prolonged period. To expect such cases to remain segregated from home in an institution with no prospects of recovery is more than can be hoped for without the continued application of compulsory powers. A further factor which gives rise to difficulty is the rooted objection which many patients have to their removal to an institution situated at any great distance from their homes. Lastly, if the segregation of advanced and incurable cases be carried out in an institution or home which is used exclusively for that purpose, it comes to be regarded as a 'home for the dying' with all the objections in the public mind which that designation connotes.

The segregation of advanced cases should be carried out in special accommodation connected with institutions used for other purposes, the provision being so spread over the area as to be within reasonable distance of patients' homes. The question of distance does not arise to the same extent in county boroughs as

it does in county districts, and it is to the latter districts that the various points now under consideration chiefly refer. The wider question of the institutional treatment of tuberculosis is considered in a subsequent chapter, but it is necessary to refer here to its relationship to the method which is adopted for the provision of accommodation for advanced and incurable cases of tuberculosis.

In county areas it is desirable to decentralize accommodation for advanced cases of the disease and to make the necessary provision by means of smaller units to serve separate well-defined districts. These units which must be specially designed for the purpose should be provided in connexion with existing institutions, namely isolation hospitals or public assistance institutions. The isolation hospital with a separate and distinct unit has definite advantages for this purpose, and there is much to be said in favour of the view that while the County Authority should be responsible for dealing with cases of tuberculosis which are likely to improve under treatment, the Local Sanitary Authority should be made responsible for the provision of accommodation for advanced and incurable cases of the disease. If public assistance institutions are used for the purpose, a separate unit should be provided. Chronic ambulant patients who give no evidence of any further response to treatment and who have to be admitted to public assistance institutions primarily for social reasons can be accommodated in specially designed balconies.

The medical assessment of all cases, even such as may appear hopeless, should receive due consideration. Doubtful cases should have the benefit of observation and treatment in a tuberculosis hospital or in the hospital unit of the sanatorium hospital where modern remedial measures both medical and surgical are available. No case should be relegated to a unit for advanced or incurable cases until the prospects of improvement under treatment have been fully explored. It is necessary therefore that there should exist a closely connecting link between the hospital department and the unit for advanced and incurable cases.

The compulsory removal of infectious persons suffering from tuberculosis of the respiratory tract is provided for by the Public Health Act, 1936. Under section 172 of the Act the County Council or Local Sanitary Authority are empowered to make application to a Court of Summary Jurisdiction for an order for

removal to an institution of a person suffering from tuberculosis, provided that (*a*) the case is infectious and proper precautions against the spread of infection cannot be taken, (*b*) serious risk of infection is caused to others, and (*c*) accommodation is available in a suitable hospital or institution.

The Court can order the person to be removed to an institution and to be retained there for a period not exceeding three months. Application for a renewal of the period must be made before the expiration of any period for which an order was obtained. At least three clear days' notice must be given to the person or to his representative in respect of whom application is to be made. The Court has power to require the patient to be examined by such medical practitioner as it may direct. The Court has also power to direct that the County Council or Local Authority making the application shall pay the whole or part of the cost of removal to and maintenance in the institution of the patient.

REMOVAL OF CONTACTS. A logical preventive procedure is the removal of young contacts from homes in which there exist open cases of tuberculosis. This method of protection which originated in France, is known as the Grancher System. Its aim is to remove young susceptible contacts from infected homes, especially those which are overcrowded and insanitary, and to bring them up under conditions which are free from risk of infection and which will encourage the development and maintenance of a higher degree of resistance by improvement in nutrition and by healthy surroundings. The first important step in the system is the removal of young contacts, especially under the age of three, who are tuberculin negative, and the younger the child the more urgent is the necessity for removal. The removal of contacts who are tuberculin positive is also indicated for the two-fold reason that not only does it provide an increased measure of resistance to combat the infection which is already present, minimal though it may be, but it prevents the occurrence of further infection. Hebert emphasizes the importance of three medical desiderata in approaching the examination of contacts, namely the few recognizable symptoms and signs in many cases of incipient tuberculosis, the long latent period between infection and clinical disease, and the necessity for special attention being paid to adolescents and young adult contacts. Kayne, who has

studied the subject somewhat extensively states that the removal of a contact before infection has actually occurred will ensure protection at least up to the age of four years and also that the segregation of an infant already infected may protect the infant from clinical tuberculosis.

The London County Council has organized a scheme for the boarding out of child contacts of persons suffering from tuberculosis. The writer is indebted to Sir Frederick Menzies for the following particulars regarding the operation of the scheme.

The Minister of Health has exercised his powers to authorize the local tuberculosis authority to board out contacts as regards London in Regulations known as the County of London (Tuberculosis) Regulations, 1930. The Regulations authorize the Council to maintain, or arrange for the maintenance otherwise than in their homes, of children living in the Administrative County of London, in houses where, owing to overcrowding or otherwise, they are, in the opinion of the County Medical Officer, in danger of being infected with tuberculosis, or whose parent or parents are receiving residential treatment for tuberculosis and for whose care adequate arrangements cannot otherwise be made.

The Council boards out children for whom no other arrangements are possible, and who live in homes in which there would be risk of infection for the children if they remained in the home; and also boards out children when the parent or parents are undergoing residential treatment for tuberculosis. Recommendations for boarding out are made by the Metropolitan Borough Council Tuberculosis Officers, each case being dealt with on its merits and no specific standard of overcrowding or otherwise is adopted. Except when children are boarded out to enable the parent to undergo residential treatment for tuberculosis, authority for boarding out is given only when the parent concerned has, or recently had, positive sputum.

When parents are offered the boarding out of children, they are informed that the boarding out will be provided free of charge, but that voluntary contributions will be accepted from those who feel they would like to make a payment and can afford to do so. Children are only boarded out when the parents agree. If, while children are boarded out, the parents demand their discharge,

arrangements are made accordingly, although, if the risk of infection appears to justify such a course, the Tuberculosis Officer endeavours to dissuade the parents from pressing for the discharge of their children.

As regards the selection of foster parents and the homes in which children are placed, the Invalid Children's Aid Association make all arrangements on behalf of the Council. They inspect the homes of those persons who offer to accept children, make the necessary selections, and also make all arrangements for their conveyance to and from the homes of the foster parents. The foster parents whose services are utilized live in areas outside the County of London, the majority of them in rural areas. Children from two years of age upwards are usually sent to these homes, and in such cases the normal rate of payment to the foster parents is 14*s.* weekly. Infants, however, are invariably placed in children's homes and hostels within the London area. Although all children boarded out are certified to be medically fit, in the case of infants special care is necessary. For infants placed in these homes and hostels the normal rate of payment is up to £1 weekly.

A scheme for the boarding out of young contacts has been in operation in the County of Surrey since 1936. The actual working of the scheme has been described by Ferguson and may be briefly summarized as follows. Children are accepted for boarding out after due consideration has been given to the question of infectivity and to the condition of the home. Every contact child under consideration is examined clinically and radiologically to exclude the presence of clinical infection. All contact children boarded out within the county are kept under observation by the Tuberculosis Officer, while children not over the age of nine also come within the purview of infant life protection. Where there are several children in one family to be boarded out and the parents have expressed a wish that they should not be separated, use has been made of larger foster-homes privately managed by trained nurses and over which the Surrey County Council has some measure of control. Contacts are boarded out by the Children's Aid Society or by the staff of the County Medical Officer in small homes or in larger foster-homes. As many of the children come from poor families, clothing and

special attention have frequently to be provided. The cost of placing these contact children varies from 12*s.* 6*d.* to 17*s.* per week, and there were about fifty children boarded out under the scheme which has proved so successful that difficulty is being experienced in finding sufficient foster homes of a suitable character.

PREVENTIVE PROPAGANDA. So much can be done in controlling and preventing the spread of tuberculosis by simple measures based on accurate knowledge, that importance must be attached to the role of education in prevention. The practical application in the home of the simple laws of hygiene, the recognition of the necessity for a balanced and adequate diet, and the carrying out of recognized measures against infection are essential to secure a further decrease in the incidence of the disease. There is some tendency to make popular education in health too technical in character and to overlook the fact that the simple lines of approach are more likely to yield the best results in regard to the inception of knowledge. The main principles to be inculcated with a view to prevent tuberculosis is to know how to provide a diet which will maintain nutritional resistance at a protective level, to appreciate and to apply the practical measures which are necessary to prevent infection, and to secure domestic and personal cleanliness and the admission of moving air and sunlight to the home.

There are various methods by which the spread of knowledge in matters relating to health may be disseminated. The foundation of such instruction should be laid down in the school, and should consist of recognized systematic courses of instruction in domestic and personal hygiene, cooking, and food values, and generally how to conserve health and well being. The Press provides through the medium of special articles an important and far-spreading means of bringing enlightenment on health problems to the homes of the people. Special health literature, including leaflets and posters, and health lectures are also much used for the purpose of imparting knowledge. The Central Council for Health Education is the principal body for organizing propaganda work in connexion with Public Health services, and provides for this purpose experienced lecturers and particulars regarding health films. The Central Council has carried out a very complete survey of the results obtained from propaganda

work and of the practical steps which are taken to encourage people to avail themselves more widely of special anti-tuberculosis services. The health film is now extensively used for instruction in matters relating to health, and this method of propaganda is utilized by the National Association for the Prevention of Tuberculosis.

The British Broadcasting Corporation includes in its programme short talks on health and hygiene, dealing almost exclusively with preventive action. These talks reach a large audience, and if they are listened to and duly appreciated they must constitute a valuable means of disseminating knowledge on the subject. The spread, by this method, of knowledge as to the importance of clean milk production and the necessity of the protection of milk from contamination by tubercle bacilli and other organisms of disease is of value. Special leaflets and posters dealing with the causes and prevention of tuberculosis are issued by Public Health Authorities and by the National Association for the Prevention of Tuberculosis. In connexion with such instruction Veronica Dawkins, however, gives expression to a note of warning. She draws attention to the difficulties to be experienced in anti-tuberculosis propaganda after the age of fifteen, especially in young females, owing to the horror of tuberculosis experienced by many and to their disinclination to approach the subject with a view to enlightenment. She advocates a cautious approach in publicity methods. In the United States and in Germany anti-tuberculosis propaganda is linked up with schemes of insurance.

In tuberculosis institutions lectures are invariably given to patients on measures to be adopted for protection against infection and regarding the steps to be taken to maintain resistance against the disease. The tuberculosis institution thus acts as a centre from which, through the medium of ex-patients, knowledge is disseminated on practical measures of prevention. Health exhibitions are also employed for propaganda purposes. The tuberculosis exhibition arranged by the National Association for the Prevention of Tuberculosis is well known and includes the following sections:

(1) Extent of Tuberculosis—the statistical section: the relative mortality from the disease; its decline; its economic importance from its heavy

incidence on the working years or prime of life; the conditions favouring its spread—insanitation, overcrowding, poverty, and unhealthy occupations—illustrated by diagrams, statistical tables, etc.

(2) Causation of Tuberculosis—the pathological section; the tubercle bacillus and its effect on the various organs, demonstrated by photographs, microphotographs, lantern slides, and actual specimens.

(3) Where Tuberculosis Lurks—which contains posters, photographs, and models of insanitary, unhealthy, ill-ventilated dwellings and rooms, back-to-back houses, etc.

(4) How Tuberculosis is Spread deals with the modes of actual infection—by coughing; by dust infected from dried expectoration; through the medium of milk, etc.

(5) How Tuberculosis is Prevented—the converse of the two preceding sections, contains photographs and models of rooms similar to those in section 3 rendered clean, sanitary, and well ventilated, showing the importance of abundant fresh air, the disinfection of sputa and of infected rooms, the pasteurization of milk, etc. Instructions about food are given in this section.

(6) How Tuberculosis is Cured—illustrates sanatorium treatment, the working of the dispensary system and home treatment by the use of balconies, roofs, shelters, garden tents, etc.

(7) Tuberculosis in Children. A special effort is made to make clear the various forms of tuberculosis in childhood and their essential unity in order to refute the popular idea that consumption of the lungs, which is relatively uncommon in childhood, is the only tuberculous disease. Sanatorium and hospital life for tuberculous children is illustrated in order to arouse the interests of the parents as well as the value and mode of working of open-air schools. At the exhibition, popular lectures, homely talks, and, where possible, lantern demonstrations on tuberculous meat are also given.

Chapter Eight

THE MODERN TREATMENT OF TUBERCULOSIS

THE modern treatment of tuberculosis in this country was initiated by voluntary effort with the provision of special institutions for the reception of persons suffering from the disease. The National Insurance Act, 1911, was the first comprehensive legislative measure which enabled state-aided institutions to be established for the treatment of tuberculosis; subsequently under the Public Health (Tuberculosis) Act, 1921, the duty devolved upon County Councils and County Borough Councils to provide comprehensive schemes for the treatment of both insured and uninsured persons. The necessary power to establish such schemes is now provided under the Public Health Act, 1936.

The aim of the treatment of disease is to promote recovery and to secure a return to partial or full working capacity, and in the case of communicable diseases to prevent contagion passing to healthy individuals. As tuberculosis is a communicable disease, it is necessary in reviewing the various units which comprise a scheme of treatment to keep in mind the influence they may exercise in relation to prevention and the dual purpose which they consequently serve. When one is closely and continuously concerned with the clinical aspects of tuberculosis it is liable to be regarded as a morbid entity requiring special attention in relation to diagnosis and treatment, while the importance of viewing it as an index of the health standard and social conditions of the community is less likely to receive the attention it merits.

ADMINISTRATIVE TUBERCULOSIS SCHEME. A tuberculosis scheme to be complete must include provision for the diagnosis and treatment of all types and forms of the disease, and facilities for after-care and prevention. It must also be linked up with co-existing public health services which directly or indirectly bear on the question of prevention, or which may be utilized to assist in conserving the results of treatment.

The following is the provision necessary to a complete tuberculosis scheme as outlined by Sir Arthur MacNalty:

I (*a*) Staff.

1. The County or County Borough Medical Officer of Health as administrator and organizer of the scheme.
2. The Tuberculosis Officer.
3. The Medical Superintendent of Sanatorium and Hospital.
4. The Health Visiting and Nursing Staff.

(*b*) The Dispensary.

II. Institutions for the Treatment of Tuberculosis.

1. The Sanatorium.
2. The Hospital, when practicable (1) and (2) should be included in
3. The Combined Institution for treatment, occupational therapy, and employment (Hospital, Sanatorium, Training Colony, and Village Settlement).
4. The Home for advanced cases.

III. Institutions for the treatment of tuberculosis in children—Children's Sanatoria.

IV. Institutions for special forms of tuberculosis.

1. Institutions for the treatment of surgical tuberculosis (in connexion preferably with a comprehensive orthopaedic scheme).
2. Hospitals undertaking the treatment of other special forms of tuberculosis (lupus, scrofuloderma, genito-urinary tuberculosis).

V. Arrangements with general hospitals or special clinics for differential diagnosis and for the treatment of complications.

VI. Institutions and arrangements for training and after-care.

1. Technical training—sanatoria of adolescents.
2. Industrial Centres—residential and non-residential.
3. The Village Settlement.
4. The Care Organization.

The various units in the above scheme must make contact where practicable with Maternity and Child Welfare schemes, the School Medical Service, Public Assistance and other public health services which directly or indirectly deal with the disease.

The first aim of co-ordination should be to direct all doubtful, suspected or potential cases of tuberculosis for investigation under the tuberculosis scheme and if necessary for appropriate treatment. The importance of close association between infant welfare centres and the tuberculosis service cannot be too strongly emphasized. At these centres young children are seen at an age which varies from a few weeks to five years, the period of life when primary infection most frequently occurs. The Medical Officer of the infant welfare centre should make a practice of investigating the family history of infants attending the centre and be on the *qui vive* for children who are 'suspect' or are obviously exposed to risk. The children who come within the ambit of the school medical service to whom special attention should be given are those in the twelve plus age group, as they are approaching the critical period of life when latent foci are liable to become activated. The position of the open-air school is an important one in relation to the protective treatment of children of school age who have had a primary infection without clinical manifestations of the disease.

The Public Assistance Service also has important points of contact. Chronic ambulant and senile cases of the disease frequently drift into public assistance institutions, and occasionally acute cases are also admitted. A special problem which calls for close co-operation is that of the tuberculous casual. Here there is a section of the population not adequately nourished, subject to exposure and hardship, and moving about from place to place, and which exercises little intelligent care in regard to protection or prevention. The arrangements which have been made for the examination of casuals by medical officers of public assistance institutions have, however, improved the position, and have been instrumental in the detection of cases of tuberculosis which would otherwise have been overlooked. The Medical Officer of the institution must be alive to the importance of detecting the latent or chronic type of the disease in casuals. The admission of tuberculous casuals to suitable institutions for treatment is greatly facilitated by the powers of retention in Public Assistance institutions available under the Poor Law Act, 1934.

PERSONNEL. The staff necessary for the efficient carrying out of a comprehensive scheme of treatment of tuberculosis is a

varied one, and as more specialized forms of prevention and treatment come into practice it becomes augmented by the inclusion of special officers and medical practitioners.

The Medical Officer of Health of a county or county borough is the chief executive officer, and he is responsible, unless his council otherwise directs, for the administrative control of the general scheme and for providing that the preventive measures which must be taken in association with the scheme are duly carried out. Special duties in regard to preventive action devolve on the Medical Officer of Health of county boroughs and urban and rural districts. Article 11 of the Public Health (Tuberculosis) Regulations, 1930, provides that the Medical Officer of Health on receipt of the notification of a case of tuberculosis, shall make such inquiries and take such steps as are necessary to investigate the source of the disease, to prevent the spread of infection, and to remove conditions favourable to infection. In the case of a patient in an institution not belonging to the Local Authority, the consent of the managers is necessary before any action under this Article can be taken. Medical Officers of Health are now appointed under sections 103 and 107 of the Local Government Act, 1933, and their general duties are defined in Parts II and III of the Sanitary Officers (Outside London) Regulations, 1935.

The Tuberculosis Officer is primarily responsible for the general clinical work connected with the scheme. On him rest the responsibility of the diagnosis of the disease in its early and curable stages, the allocating of different types of the disease to appropriate forms of treatment, the examination of suspects and contacts, the carrying out of remedial and curative measures, some of which are of a highly technical character, and the taking of special action with a view to prophylaxis, more especially the prevention of contact infection. Tuberculosis officers are usually whole-time officers, exclusively concerned with the disease, but in some districts medical practitioners who undertake various public health services also act in the capacity of tuberculosis officer for their district and administratively this arrangement has some definite advantages, although it is doubtful whether it provides such a high uniform standard of clinical efficiency. In some districts the administrative duties in connexion with the Tuberculosis Scheme are carried out by a Chief Tuberculosis

Officer, in other districts where the County or Borough Medical Officer of Health acts as administrative officer, a Chief Clinical Tuberculosis Officer is appointed.

A Tuberculosis Officer is defined as a Medical Officer in clinical charge of a tuberculosis dispensary provided by a Local Authority. The qualifications of a tuberculosis officer or a Medical Superintendent of a sanatorium are defined by the Local Government (Qualifications of Medical Officers and Health Visitors) Regulations, 1930, as follows: (1) has had three years experience in medical practice; (2) has spent in general clinical work a period of not less than eighteen months, of which not less than six months have been in a hospital, and (3) has received special training for a period of not less than six months in the diagnosis and treatment of tuberculosis.

It is important that the tuberculosis officer in carrying out his clinical duties should keep in close contact with other departments of the public health service with a view to co-ordinated action whenever practicable.

The Medical Superintendent is defined as a medical officer in clinical charge of a residential institution of not less than seventy-five beds for the treatment of cases of tuberculosis in the early curable stages of the disease, and the qualifications necessary for the appointment are similar to those which govern the appointment of a tuberculosis officer. The duties of a medical superintendent are both administrative and clinical, and in connexion with the latter duties it is essential that he should be in close and continued contact with the tuberculosis officer.

A staff of experts or consultants must necessarily be associated with the tuberculosis service. The varied manifestations of tuberculosis make it necessary from time to time to have the services of a surgeon, orthopaedic surgeon, ophthalmic surgeon, dermatologist, laryngologist, dental surgeon, and other experts in special branches. The advance which has been made within recent years in the surgical treatment of pulmonary tuberculosis also requires the services of a surgeon who specializes in this particular branch of chest surgery.

The General Practitioner must be regarded as an important unofficial member of the service. He comes frequently into direct contact with patients and members of their families in their homes,

and he is frequently consulted by patients suffering from the disease in the early stages of its development. He is responsible for the domiciliary treatment of cases of tuberculosis, and attends them in the advanced and most infective stages of the disease, when his advice on palliative and prophylactic measures can be of real practical value. The medical practitioner is in a position to have first-hand knowledge of the family history and domiciliary conditions relating to the individual suffering from the disease, and to give valuable assistance in the detection of early cases of clinical infection by referring suspected cases, or members of suspected families, for investigation and in urging necessary action with a view to prevention in the home. It is necessary that there should be close and intimate co-operation between the general practitioner and the tuberculosis officer.

The Sanitary Inspector who is now appointed under section 107 of the Local Government Act, 1933, or section 9 of the Public Health (London) Act, 1936, is responsible for very important measures in relation to the prevention of the disease. As part of his routine duties he becomes conversant with the sanitary standard of the houses in his district, the degree of overcrowding, and the extent to which the hygienic conditions in the home call for improvement. He is in a position to report to his medical officer of health and to secure through him structural and other measures of improvement in domiciliary conditions. He is responsible for the work of cleansing and disinfection of rooms and clothing and for supplying disinfectants when necessary. In county districts the appointment of a county sanitary inspector is necessary to carry out efficiently the duties relating to housing and tuberculosis and to co-ordinate preventive action. The general duties of sanitary inspectors outside London are defined in Part IV of the Sanitary Officers (Outside London) Regulations, 1935.

The Tuberculosis Visitor has special duties assigned to her in relation to tuberculosis which include the visitation of notified cases of the disease, the submission of reports regarding home conditions and the giving of advice as to prevention and after-care. To this may be added in certain districts attendance at tuberculosis clinics and the actual nursing of patients in their homes. The tuberculosis visitor may be a whole time officer, or, as is the case in many rural districts, she may combine

tuberculosis work with other duties, such as health visiting, school nursing, and domiciliary midwifery.

The special qualifications of a tuberculosis visitor are defined in the Local Government (Qualification of Medical Officers and Health Visitors) Regulations, 1930, which require that she must be qualified as a health visitor or is a fully trained nurse who has had three months experience at a sanatorium, a tuberculosis hospital or a tuberculosis dispensary. These conditions do not apply to a person who has held the appointment of tuberculosis visitor prior to April 1st 1930.

Without the active co-operation of the patient the treatment of tuberculosis will be unsuccessful, and efforts at prevention will be seriously prejudiced. The tuberculous patient must be an active and not a passive resister. Patients not infrequently hold the view that the responsibility of a successful response to treatment rests with the doctor and nurse, and with them alone, and that there is no call for the patient to make any effort to assist in securing this end. It is necessary to advise patients that the arrest or eradication of disease cannot by the laws of nature but be associated with some measure of discomfort, and that the active and intelligent co-operation of the patient is an essential factor in the successful treatment and prevention of the disease.

UNITS OF SCHEME OF TREATMENT. The tuberculosis dispensary or clinic has long been regarded as the first essential unit of any comprehensive scheme for the treatment of tuberculosis. It had its origin in this country in the Royal Victoria Dispensary in Edinburgh, which was established by Sir Robert Philip in the year 1887. The function of the dispensary is to serve as the centre for diagnosis, examination of contacts, observation, special treatment and after-care, and for the dissemination of knowledge regarding the measures to be adopted for protection against the disease. It should provide, either directly or indirectly, facilities for bacteriological and pathological investigations and for radiological examinations. It provides also a bureau for the filing of records and statistics and is an important unit in the scheme of after-care, as it constitutes an essential link between the tuberculosis officer and the ambulant tuberculous patient; an aspect of its function which is much appreciated by the intelligent patient.

The most important residential unit for the treatment of cases of pulmonary tuberculosis is the sanatorium, or as it is now termed the sanatorium hospital. The sanatorium, as originally designed, was intended for the conservative treatment of early cases of the disease on open-air lines. Development, however, during recent years has been in the direction of combining sanatorium and hospital accommodation in the one institution, and it has indeed reached the further conception of a composite institution which provides under the same administration a number of units including sanatorium, hospital, industrial colony, and village settlement. One advance which has been made in the institutional treatment of the disease is the closer attention which is paid to the question of classification which is now rendered possible by the application of hospital principles to the sanatorium. For practical purposes tuberculous patients admitted to a sanatorium are divided into three groups, namely (1) ambulant, (2) non-ambulant, including acute and advanced cases, and (3) cases for investigation. To secure accommodation for these three groups it is necessary that separate provision should be made.

Special accommodation should be considered for expectant mothers suffering from active tuberculosis. In a memorandum on tuberculosis and pregnancy which has recently been issued, by the Tuberculosis Group of the Society of Medical Officers of Health, it is recommended that unless conditions are especially favourable, no pregnant woman should be delivered at home. Sanatorium treatment should be advised until the end of pregnancy, and delivery should take place in a sanatorium where suitable facilities exist, or in the isolation ward of a maternity hospital. A further period of sanatorium treatment after delivery is necessary, as it is at this stage that there is an increasing tendency to relapse.

It is not recommended that provision should be made in county districts for advanced and apparently incurable cases which are obviously nearing their end, in connexion with the sanatorium, except in so far as such cases are admitted for purposes of observation to determine whether some form of special surgical or palliative treatment is indicated. Provision for these advanced cases should be made elsewhere.

The original conception of the sanatorium as an open-air

institution for conservation treatment has altered and now approximates more closely to that of a hospital both in design and internal administration. While the character of the provision in institutions for the treatment of respiratory tuberculosis varies in different localities, the broad principles which govern design and arrangements are now generally accepted and have been outlined in the Final Report of the Departmental Committee on the cost of hospitals and in the Report of the Joint Tuberculosis Council. The main recommendations as to details of construction and arrangement from these reports are submitted in the following summary.

Site: Less importance is now attached to the position of the site; it should preferably be in the country but reasonably accessible, be dry and fairly level, and if possible be linked up with public services. The area of the site should be adequate both for immediate requirements and possible developments in the future.

Size of Institution: This necessarily depends upon a number of factors, the chief one being the system which is adopted in dealing with the different types of the disease. The size may vary from a small institution of seventy beds or less to a large institution of 200 beds or more. The large or medium-sized institution is to be preferred to one of smaller type, and local authorities may combine to provide this.

Departments: These include ward blocks, treatment unit containing consulting-room, X-ray-room, dark-room, film store, treatment-room, waiting-room, cubicles, dispensary, dental-room, laboratory, and, for non-pulmonary cases, an artificial-light-room and plaster-room. The size of the X-ray-room should be not less than 320 square feet for institutions up to 150 beds, and 415 square feet for institutions up to 300 beds. In large institutions a separate dining-room block centrally placed but near the main kitchen is required. The allowance of space in the dining-hall should be based on 14 square feet per patient for the estimated maximum number able to use the dining-hall.

Ward Units: In institutions for the treatment of pulmonary tuberculosis, the size of the unit will vary from thirty to fifty beds, divided into single-bed wards, two-bed wards, and wards with a maximum of six beds. The proportion of single-bed wards required will vary

from 15 per cent to 20 per cent. In connexion with the accommodation provided for bed cases the provision of a balcony or terrace is recommended.

The area of the wards recommended is 90 square feet for single-bed wards and 80 square feet per bed for other wards. The height of the wards need not exceed 10 feet.

Sanitary Provision: This will vary according to whether the type of case is ambulant or bed-fast. For ambulant cases the provision should be water-closets (one to eight patients), with the addition of a urinal in units for male patients; baths (one to ten patients); lavatory basins (one to six patients). In a ward unit occupied by bed-fast patients modern bed-pan sterilizing equipment should be provided.

Staff Accommodation.
Administrative Services.
Methods of Construction.
} These will conform, except in certain special details, to the provision made in acute general hospitals.

In large institutions the provision of a special surgical block to provide facilities for the modern surgical treatment of pulmonary tuberculosis will have to be considered. In smaller institutions or where institutions are suitably located, arrangements for this special form of treatment are usually made with existing special hospitals which have the necessary facilities. As the more radical forms of the surgical treatment of pulmonary tuberculosis are still to some extent in the experimental stage and a very highly skilled staff is necessary for such treatment, it is desirable to proceed slowly and with discrimination in the provision of such units. McDougall and Bardswell have voiced a word of caution in this connexion. They considered that it would be a mistake to multiply units for chest surgery in a large number of sanatoria and chest hospitals throughout the country. They emphasize the necessity for the staffs of such units to have considerable and continuous experience in the surgical methods of treatment and in the after-treatment and care of the patient. Attention is also drawn to the care which has to be exercised in the selection of cases which calls for the most considered judgment on the part of both physician and surgeon. They recommend that neighbouring authorities should combine to centralize facilities for such surgical treatment at one institution so as to secure a standard of efficiency which it would be impossible to approach with smaller scattered units.

The hospital as a separate unit in the scheme is now of less importance as a means of providing accommodation for acute cases owing to the development of the sanatorium along hospital lines. Voluntary hospitals which make special provision for diseases of the chest, including tuberculosis, which have expert medical and surgical staff, do, however, fulfil a most important function. They provide a centre for investigation of the disease and are specially suitable for the location of surgical units for radical surgical methods of treatment. The value of the work of investigation and the special treatment carried out in hospitals of this class in London is appreciated far beyond the area which they more immediately serve.

The hospital treatment of advanced and incurable cases which is purely palliative and prophylactic in character is referred to elsewhere.

The character of the institutional accommodation which it is necessary to provide for children suffering from pulmonary manifestations of tuberculosis, depends upon the extent and severity of the disease. For children with definite evidence of pulmonary disease, and for those with positive sputum, stomach wash, or faeces, a term of treatment in a special children's block in the sanatorium for adults or in a special children's sanatorium is indicated. Suspected cases of the disease should be admitted when necessary to an observation unit of the sanatorium for investigation, although in the majority of such cases, by means of tuberculin testing and radiological examination, the diagnosis can be established at the clinic. The open-air school provides the most satisfactory accommodation for children who do not require special treatment. Residence in an open-air school is instrumental in improving nutrition and in building up resistance, and it enables the growing child to combat more successfully the strain of puberty and adolescence at a later date.

The open-air school is certified as a school for physical defective children under Part V of the Education Act, 1921. Norris has given a comprehensive description of the administrative procedure in open-air schools which provide accommodation for cases of quiescent tuberculosis, suspected cases, and children whose home conditions predispose to the disease. Treatment provides for periods of rest and instruction under open-air conditions, and

temperature and weight records are kept. The presence and extent of possible infection are investigated by the employment of tuberculin tests and radiographical examinations. The school is visited by the tuberculosis officer, who acts as school medical officer.

An important unit in the scheme of treatment is the hospital for the treatment of cases of non-pulmonary tuberculosis. The modern conservative method of treatment reinforced by special surgical measures has yielded excellent results in the arrest and cure of tuberculous lesions of bones and joints and in the prevention of deformities. The modern treatment of this type of disease is provided in large institutions specially designed and specially equipped for the purpose, and having a skilled nursing, resident medical, and consultative staff. Large institutions which are capable of serving a relatively large area are to be recommended, and the accommodation provided should be adequate to meet the requirements not only of children but of adults suffering from tuberculosis of bones and joints. In some districts difficulty is experienced in securing the admission of adult male patients suffering from tuberculosis of the spine or other bony structure to a special hospital for treatment. An essential adjunct to the hospital is the orthopaedic clinic to which the patient can be referred for after-care and observation and for necessary subsequent treatment for deformity. It is important that the tuberculous patients attending orthopaedic clinics should be under the supervision of a skilled orthopaedic surgeon.

Cases of uncomplicated tuberculosis of the lymphatic glands and of the peritoneum also respond well to treatment in such special hospitals, although proximity to the sea is definitely more beneficial to some children suffering from these conditions.

For certain forms of extra-pulmonary tuberculosis, admission to special departments of large general hospitals, or failing this to small general hospitals, is necessary. Tuberculosis of the ear, eye, kidney, bladder, fallopian tubes and skin require special methods of investigation, nursing and treatment. In all cases of non-pulmonary tuberculosis which do not require specialized methods of treatment, conservative treatment in a sanatorium may be employed with good results.

PRINCIPLES OF TREATMENT. Since the beginning of the present century the treatment of tuberculosis, more especially

its pulmonary form, has passed through various phases. These include the strict régime of the Nordach method, treatment by strict rest and by auto-inoculation on the lines recommended by Marcus Paterson; specific treatment with tuberculin or serum, and the present-day method of combined conservative and operative treatment. Apart from specific treatment the same principle underlies these various methods of treatment, namely rest or immobilization of the disease structure.

Rest constitutes an important and essential part of the conservative treatment of tuberculosis. Just as pain is nature's method of securing rest of an inflamed or injured structure, as was stressed by Hilton in his classical work, *Rest and Pain*, so do raised temperature and quickened pulse-rate constitute nature's demand for rest of body to combat constitutional distubance. Conservative treatment also includes hygienic measures—exposure to moving air and measured sunlight, and adequate and balanced feeding. It is the quality and not the amount of food which is of importance. The aim of the diet must be to secure improved nutritional resistance, and in certain cases it is necessary to give supplementary substances to improve the condition of the blood. Conservative treatment in the sanatorium is frequently reinforced by chemical treatment, an example of which is the modern treatment with gold salts. Palliative and symptomatic treatment, especially in advanced cases, must also constitute part of the régime. Recently Hunter and Peill have described a new method of chemical treatment. They employ a special antiseptic medium introduced by intra-pulmonary injections with a view to promoting the calcification of localized pulmonary lesions. The medium which is termed G.A.C.C., contains gelatine, acriflavine and calcium chloride, and the authors give a detailed description of the method and of three cases of pulmonary tuberculosis with cavitation in which the treatment has proved successful in securing fibrosis and resolution. The writer's colleague, A. P. Ford, has employed this method of treatment in three cases with encouraging results.

The operative measures now employed in the treatment of pulmonary tuberculosis, aim at securing partial or complete rest of the diseased lung. Such operative measures do not, however, negative the necessity for rest in bed if, in spite of the operative

treatment, there exists evidence of systemic intoxication, as expressed by accelerated pulse rate with pyrexia of even slight range. There is a danger that the pendulum may swing too far in the direction of operative treatment. Operative measures will not alone solve the problem of the successful treatment of tuberculosis which is a general infection; for this a more direct line of assault on the entrenched tubercle bacilli is necessary. A note of warning on the abuse of surgical methods in the treatment of pulmonary tuberculosis has been sounded by Burton Wood. With reference to the more serious operative measures, he advocates an attitude of caution and restraint and states that 'we should never forget that the risk of over-treating is greater than the risk of under-treating a disease in which the prognosis is, after all, often better than we expect it to be.' The immediate results of operative treatment, more especially of treatment by induced pneumothorax, are frequently striking, but so far there is no evidence that the modern methods of treatment of pulmonary tuberculosis have exercised any appreciable and progressive influence on the case mortality of the disease. Drolet has investigated the trend of the case mortality in tuberculosis for the twenty years between 1915 and 1935 and has submitted figures which show that little change has occurred in the case mortality during these years. Drolet concludes that the sanatorium or surgical treatment of pulmonary tuberculosis would appear to exercise little influence on the case mortality rates of the tuberculous population of the communities studied. He points out, however, that the average age at which death occurs has risen. In England and Wales in 1914 it was 32·6 years for males and 29 for females· this average had risen in 1935 to 38·9 and 32·8 years respectively.

A very complete investigation as to the results obtained by sanatorium treatment in 2,750 cases at the King Edward VII Sanatorium, Midhurst, has been carried out by Brand and others and presented in a report to the Joint Tuberculosis Council. The results which were actuarily checked were inconclusive, and provided no evidence in favour of pneumothorax treatment as compared with an efficient sanatorium régime. Bentley has investigated the results of treatment by artificial pneumothorax in 677 cases undergoing this treatment under the tuberculosis scheme of the London County Council between the years

1920 and 1930. He concludes as a result of his investigation that the results of treatment of pulmonary tuberculosis cases as judged by survival after five years will be improved by approximately 4 per cent, and he regards it as a method of treatment of vital importance to selected individual patients.

Sir Percival Hartley and Wingfield, have compared the expectation of life of patients during two periods of years, 1905–14, and 1915–31, and observed little change in their after-history in the two periods except that the group treated by induced pneumothorax showed an improved expectation of life. Ford submits figures which show the results as regards increased expectation of life in twenty-five patients in whom satisfactory collapse was kept up for a period of two years or more. In 1938 the number of patients alive and well with the year when treatment was commenced is as follows: 1924, one out of three; 1925, two out of five; 1926, two out of three; 1927, three out of four; 1928, three, the number treated; 1929, two out of three; and 1930, four, the number treated. Total treated, twenty-five; number alive and well in 1938, seventeen.

The various operative measures adopted in the treatment of pulmonary tuberculosis are well known, but a description of them does not fall within the scope of this work. They include induced pneumothorax, thoracoplasty, operations on the phrenic nerve, plombage and the division of adhesions. Two direct beneficial results must be attributed to the modern operative methods of treating pulmonary tuberculosis. They increase the expectation of life and they restrict the output of tubercle bacilli.

Conservative treatment has yielded the best results in the treatment of certain forms of non-pulmonary tuberculosis. In cases of tuberculosis of bones and joints, rest, immobilization and postural treatment, supplemented by natural or artificial light, have given excellent results, although treatment has usually to be continued for a prolonged period. In certain cases operative treatment is indicated, and in spinal tuberculosis bone grafting has proved successful. In skin tuberculosis and in old-standing tuberculous lymphatic lesions, artificial light treatment has given striking results.

The specific treatment of tuberculosis by vaccine or serum, or by a combination of both, although it is the method which will

eventually solve the problem of the successful treatment of this disease, has not up to the present yielded satisfactory results. One still recalls the enthusiasm with which the first efforts at treatment with Koch's tuberculin were received, and the expectations which were raised by the introduction of the sera of Marmorek and Maragliano. When one considers the proof provided by post-mortem findings as to the frequency with which primary tuberculous lesions of the lung undergo complete healing under the influence of auto-inoculation, and when regard is given to the protective influence imparted by a healed primary infection against secondary clinical tuberculosis, even in spite of repeated exposure to infection, one is compelled to view with some degree of confidence a definite future for specific treatment.

The vicissitudes which have characterized the use of tuberculin in the treatment of tuberculosis are due to various causes. No uniform method of administration has been employed in the past, and what is undoubtedly of greater importance the strains of organism which constitute the tuberculins in common use have been cultured on artificial media which differ widely from the natural medium in the human host. In this connexion Pottenger states, 'but natural tuberculin contains some unknown substance which so far has escaped laboratory elaboration, which stimulates the body cells to a quickened and sometimes a manifold increase in their normal antibody production.'

Some years ago the writer suggested the desirability of breaking away from the existing methods of preparing tuberculin. He advocated the employment of a culture medium containing non-heated sterile blood serum under conditions approximating as nearly as possible to those under which the tubercle bacillus grows and develops in the human body. This would at least shed some further light on the true character of the toxins elaborated by the human type of organism in the process of growth under natural conditions. The placenta with its ample blood supply would provide an ever available medium for this purpose.

The specific treatment of tuberculosis in this country has suffered from the fact that no uniform method of administration has been adopted. Years ago the writer in an article on the selection of sanatorium cases for treatment with tuberculin pointed out that tuberculin containing the body of the bacillus should only

be used when all clinical evidence of auto-inoculation had ceased, and that only tuberculin containing exotoxins should be employed in cases characterized by slight persistent toxaemia, and above all that reactions must be avoided. Administered in this way by gradually increasing the dose and when necessary by repeating the same dose, tuberculin was found to increase protection against relapse by producing tolerance, and to reduce slight but persistent phases of pyrexia. In certain cases of chronic tuberculosis of bones and lymphatic glands with persistent discharging sinuses, the beneficial effect of tuberculin is frequently quite marked. Two results have been aimed at in the administration of tuberculin, namely to produce an immunizing response and to desensitize the tissues. Experience has shown that the focal reaction which is induced by attempting to force immunity is more harmful than beneficial, and that it is only by securing a progressive degree of desensitization with increasing small doses that any good result can be obtained.

Young, in reviewing the position of tuberculin in the treatment of tuberculosis, expresses the opinion that it is only beneficial when the focus of disease is localized and non-toxic, and for this reason it is more likely to be helpful in cases of non-pulmonary disease. He emphasizes the fact that there is scope for much further research work in the field of specific treatment, and he hopes that a reliable method of specific treatment will eventually be discovered, probably through the co-operation of biochemists with bacteriologists.

Wingfield states that the continual use of tuberculin by proper methods reduces sensitiveness, and if hyper-sensitiveness can be diminished by the use of tuberculin this is a sound method of treatment. Recently Wood and Randolph have investigated these two methods of administrating tuberculin in cases of ocular tuberculosis in the human subject, and their investigation has proved that the method which aimed at securing tissue desensitization has given the better results.

Although tuberculin is not now generally employed in the treatment of tuberculosis, various observers continue to believe in its value. Camac Wilkinson has for years been its most sturdy protagonist in this country. Somewhat striking figures in support of the view that tuberculin treatment increases protection against

relapse are supplied by Gillespie. In a series of sputum positive cases, classified 1 and 2 (Turban Gerhardt) the percentage of patients at work after ten years was as follows: treated with tuberculin, 33·3 per cent; treated at sanatoria, 11·8 per cent; otherwise treated, 8·5 per cent. Halliday Sutherland, who has had experience of tuberculin in the treatment of tuberculosis for a period of ten years, remains a firm believer in its value. He advocates the use of tuberculin B.E. and he emphasizes the importance of what is the real secret of its administration, namely knowing how to increase the dose, how to space the dose and how to deal with reactions, which, however, should always be avoided.

On the other hand Bardswell, who had made a careful and impartial investigation of the results of the treatment of pulmonary tuberculosis with tuberculin was unable to subscribe to the view that it is of any definite value; further, he stated that his experience was that its indiscriminate and careless use will do positive harm. Bardswell and Thompson investigated the results in 228 cases treated with old tuberculin (AF) and Koch's B.E. in King Edward VII Sanatorium at Midhurst. The conclusion they arrived at was that treatment with tuberculin had no appreciable effect either for good or ill, although possibly it was responsible for some slight improvement in Group 1 cases.

A study of the statistics of tuberculosis shows that while there has been a steady decline in the mortality rate from the disease, there has been no striking fall in the case mortality, although the age at which death occurs has risen. The decrease in the death-rate must be attributed in part to segregation of infective cases for varying periods in hospital and sanatorium and to the educative influence of residence in these institutions. The persistence of the case mortality at practically the same level suggests that our present methods of treatment are not sufficiently effective to give permanent results. Do the facts not indicate that both conservative and operative treatment must be supplemented by some form of carefully controlled specific treatment? Whatever our views may be regarding the present methods of specific treatment, it is obvious from statistical evidence that investigation in the field of specific and chemical treatment must be continued if an appreciable and progressive fall in the case mortality of the disease is to be obtained.

CLIMATIC TREATMENT. A change of residence so as to secure a change of climatic conditions has long been regarded as of value in assisting to secure arrest of the disease. The view is based on the accepted fact that fog, humidity with low temperature, rain-bearing winds and restricted sunlight, exercise an adverse influence on the health and resistance of the tuberculous patient, and consequently it is assumed that the absence of such conditions will exercise a beneficial effect. This is no doubt true in certain types of the disease, but discretion has to be exercised in the selection of patients for whom a change of climate is recommended when such change is a practicable proposition.

Certain cases of non-pulmonary tuberculosis undoubtedly benefit by removal to a district of high elevation with clear atmospheric conditions, where graded heliotherapy can be efficiently carried out. Young children also derive benefit by removal to suitable maritime districts. Cases of pulmonary tuberculosis present a more difficult problem, as the age of the patient, the type and extent of the disease and ratio of resistance must be carefully studied before the decision is made that a change to a district with better climatic conditions is desirable. One definite drawback, especially in the case of the patient who is not conscious of serious physical disability, is that in the absence of competent supervision, with its controlling influence, undue effort and indifference to ordered routine may lead to exacerbation and relapse. For the young adult with pulmonary tuberculosis, residence in a sanatorium in this country where modern methods of treatment are efficiently carried out is the better choice. A preliminary investigation has been carried out by Price and Sandison as to the results of treatment abroad in Switzerland, the Riviera, and other localities, of 251 sputum positive cases of pulmonary tuberculosis in ex-officers and nurses during three periods, 1919–1922, 1923–1926, and 1927–1936. They conclude that after making all allowance for age and other obvious factors, an analysis of the results does not show that the mortality amongst these cases is any less than that to be expected on the basis of comparable statistics of mortality amongst cases not treated abroad; indeed, rather the reverse is indicated.

Cases of active pulmonary tuberculosis should not be sent

abroad except to a sanatorium where efficient conservative treatment is carried out. Ambulant cases of fibrotic type no doubt benefit from residence in warm sunny districts free from excessive dampness and fog, but such cases should not be sent to high altitudes. The benefit which may accrue from residence abroad depends upon the habits and the psychology of the patient, and upon the efficient character of the accompanying treatment which is carried out.

DOMICILIARY TREATMENT. At some stage in the course of illness and incapacity, treatment in the home is necessary. It is called for during the period of waiting for admission to an hospital or sanatorium, and at this period the value and importance of treatment by rest to keep in check the progress of the disease must be emphasized. Preventive measures which aim at restricting the output of tubercle bacilli so as to minimize the risk of infection to others also constitute an important part of domiciliary treatment. Under certain home conditions efficient domiciliary treatment is impracticable, but even under adverse conditions pending removal to hospital or sanatorium, the aim of treatment should be to secure rest in bed in a single room, adequate nourishment and the regular use of the sputum cup and sputum flask. Isolation and rest are two most essential principles in relation to prevention and treatment in the home.

Domiciliary treatment must never be considered as an alternative to institutional treatment unless the conditions of the home and the circumstances of the patient are such as to enable a high standard of treatment to be maintained and efficient preventive measures to be carried out. This requires a satisfactory standard of home conditions, a separate room for the patient, sufficient means to provide adequate nourishment and other necessities, and skilled medical and nursing attendance. If the house has a garden the provision of a suitable shelter will secure a greater degree of segregation.

Chapter Nine

THE CARE AND EMPLOYMENT OF THE TUBERCULOUS PATIENT

THE role of tuberculosis as a cause of unemployment and consequent poverty has long been recognized, and the practical measures to be adopted to provide some solution of the economic problem resulting from the disease are now receiving increasing attention. The wage earner who is attacked by tuberculosis, has sooner or later to cease work either through physical disability or for the reason that he is called upon to undergo a term of treatment in a sanatorium or hospital. In the case of an unskilled worker or casual labourer the vacancy is usually immediately filled up. If the patient is a skilled worker his place may or may not be retained for him according to the prospects of recovery and the attitude of the employer. Moreover, if the occupation which has been followed be one which is regarded as likely to predispose to the disease or requires the ex-patient to come into close contact with young susceptibles, even when apparently restored to health and working capacity, a return to the previous employment is not desirable. In this connexion the problem of the tuberculous mother is one which calls for special consideration.

Tuberculosis represents a financial loss to the nation of many millions of pounds. It is a frequent cause of disability and death at the most active stage in life, when the capacity for work and earning wages stands at its highest level and when the family of the stricken wage earner is entirely dependent upon his working capacity for the necessities of life. Tuberculosis is a great cause of poverty, and as poverty is a recognized predisposing cause of tuberculosis we have constituted a vicious circle which it is essential should be broken. The position has been clearly defined by Sir Pendrill Varrier-Jones, who states: 'Illness leads to unemployment, unemployment to short commons, short commons to malnutrition, malnutrition to lowered resistance, and lowered resistance to the contraction of the disease.'

THE AIM OF AFTER-CARE. The term after-care is a comprehensive one and refers to the assistance, supervision, and treatment which are necessary after a term of institutional treatment has been completed. It also includes measures which aim at the control of infection. In discussing the importance of after-care, the Chief Medical Officer of the Ministry of Health has emphasized that a man with arrested pulmonary tuberculosis requires care and medical supervision, especially during the critical five years following arrest, and that if such a man is placed in competition with healthy labour in the open market he more frequently than not breaks down, and that it is this sociological factor that vitiates so frequently the successful results of sanatorium and hospital treatment. Brieger has described the functions of after-care as threefold: namely medical, preventive or social hygienic, and sociological.

After-care is an essential adjunct to the treatment of tuberculosis, and is necessary for the patient through all stages of his illness, except when resident in hospital or sanatorium—its main sphere of activity both as regards assistance and prevention applies to the patient who is residing at home. Intelligent and practical after-care, by providing measures to combat infection and by assisting to prevent relapse in arrested and quiescent cases, plays an important part in restricting the incidence of the disease.

The chief aim of care and supervision is to maintain the individual with arrested or quiescent tuberculosis as a cog and not a clog in the machinery of national life. Such care and supervision must, therefore, aim at providing the following: (*a*) extra nourishment and clothing; (*b*) assistance to conserve working capacity and to obtain suitable employment; (*c*) assistance to dependants of patients; (*d*) assistance to obtain a suitable house or to secure necessary alterations to improve housing conditions, including the provision of shelters; (*e*) assistance to secure special forms of treatment and appliances, and (*f*) the protection of contacts against infection.

SCHEMES OF AFTER-CARE. The development of schemes of after-care has been directed along two main lines, namely the care of the patient as a unit of tuberculosis in the family, and the care of the patient with a view to securing and maintaining the highest standard of working capacity of which

he is capable. These present two distinct yet related problems. The actual administration of after-care is carried out by an official, by a voluntary after-care committee or by the tuberculosis officer in co-operation with the Public Health or Tuberculosis Committee. Bardswell, in describing the system of after-care for tuberculous patients in London, had stated that he inclines to a care committee with a good secretary. He had pointed out that the inspiring agents of the scheme are the tuberculosis officer and the secretary, and that what happens to the patient and his dependants after leaving the sanatorium or hospital is what really matters. The difficulties to be overcome in the administration of a practical scheme of after-care are much greater in some districts than others. After-care presents quite a different problem in a county area with small urban districts and a scattered rural population to that in a compact self-contained borough. In county areas the chief point of contact is provided by the tuberculosis visitor or the village nurse.

The constitution of the care committee depends upon the view taken by the Public Health Authority; it may be an official or a voluntary committee. Bardswell favoured the voluntary principle and the usefulness of a committee composed of interested members who are prepared to give personal service to particular patients. The voluntary principle has mainly been adopted in London.

One difficulty which arises in connexion with voluntary care committees is the question of funds. In considering the question of after-care in relation to tuberculous patients it is necessary to have in mind two important facts, namely the chronicity of the disease and the partial disability in many cases, and the fact that depletion of income in the case of a tuberculous family is aetiologically of greater importance than in the case of almost any other disease. In this connexion reference may be made to a social service provided in Canada, which is of special value in relation to the after-care of tuberculous patients. In that country Wodehouse informs us that a mother's allowance is provided, which in the event of the father's death enables her to retain her children in the home and make provision for them; if the father of a family becomes tuberculous the State treats the family as if the man were dead, so that the mother becomes eligible for the State allowance. This is a real contribution to the problem of

after-care. The tuberculous family can ill afford depletion of income which means depletion of food, at the time when the members of the family are exposed to the risk of infection, owing to the presence of a member with clinical tuberculosis, and when an increased amount of suitable food to raise the standard of resistance has become necessary.

The conception of an efficient scheme of after-care is one which would combine enlightened and sympathetic voluntary help with the capacity to give assistance, either financial or in kind.

AFTER-CARE AND TREATMENT. The chronicity of the disease in many cases of tuberculosis demands a close co-ordination between care, supervision, and treatment. To maintain the improvement which has been secured by a term of institutional treatment calls for a prolonged effort on the part of the patient, and sympathetic encouragement and practical help to persevere.

The ambulant patient who is able to attend the tuberculosis clinic without risk of strain will derive benefit from the advice and supervision which contact with the clinic provides. On the other hand, a patient with even a slight tendency to reaction on effort may undo such benefit if attendance at the clinic involves such degree of exertion as will induce reaction. Sustained contact with the clinic also secures an educational influence which is of real value to the patient. The checking of the temperature chart and of the weight records supplies necessary information, without which an accurate estimate of the patient's condition and progress is impossible. Associated with this the physical examination of the patient provides for the early recognition of the first evidence of relapse from recrudescence of the disease. And the knowledge of this imparts to the patient confidence in the clinic as a medium for providing expert care and supervision. The efficient care and control of patients attending tuberculosis clinics is not, however, possible without home visitation and supervision, and for this reason there must be an active liaison between the clinic and the home of the patient.

When the patient is under domiciliary treatment active care and supervision are especially essential. From the point of view of prophylaxis it would be a great advantage if every patient with open tuberculosis could throughout the course of the disease be

segregated and treated in an institution, but for obvious reasons this at present is impracticable. Special supervision must, therefore, be directed in the case of domiciliary patients to the efficient carrying-out of preventive measures. The tuberculous patient in his home requires constant encouragement to persevere in carrying out preventive measures, and it is to the health visitor and tuberculosis nurse to whom we must look for that measure of home control and personal contact with the patient which is so essential to successful prophylaxis.

To assist in the efficient care of the patient in his home ancillary provision is necessary. Adequate food and clothing, especially bedclothes, alteration in the structure of windows, and the provision of better housing conditions are necessary. Most important of all is the question of food, as is shown by the rapidity with which weight is frequently lost after sanatorium treatment has been discontinued. Where the income of the family is insufficient to provide an amount of food adequate for the needs of the patient, and for the protection of the members of the family, some assistance in money or in kind must be given. Mark Fraser emphasizes the practical value of a pension scheme for persons suffering from pulmonary tuberculosis with positive sputum. Under the scheme the pensioner would be required (*a*) to submit to regular medical examination, (*b*) to undergo such treatment as might be considered necessary, (*c*) to conform to a mode of life which would eliminate as far as possible all risk of infection to others, and (*d*) to allow his children to be periodically examined.

Whatever method be adopted to assist tuberculous patients, chief consideration should be given to the question of food, not only from the patient's point of view, but in relation to the resistive capacity of the members of his family. It is for this reason that family food tickets would be of greater practical value than financial assistance, as this would secure, without any possibility of doubt, that the food available in the home was being augmented by a known additional amount.

EMPLOYMENT. With few exceptions an individual who has or has had a positive sputum must be regarded as a damaged life with an impaired capacity for work under normal conditions. Bashford and Scott have investigated the after-history as regards capacity for work of 3,755 cases of pulmonary tuberculosis. They

conclude that of those who develop pulmonary tuberculosis not more than 50 per cent are able to return to work, and of those who do there is a further wastage of 48 per cent within ten years from recrudescence or intermittent illness. The authors conclude from their analysis that there is less wastage due to recurrent tuberculosis in light manual or clerical indoor-workers than in manual mainly outdoor-workers. In regard to tuberculosis of bones and joints, while it frequently undergoes a complete cure, it may leave as a sequela a degree of deformity which constitutes a definite disability for competition in the open market.

Employment in relation to the tuberculosis patient presents, therefore, a very definite problem to solve which various methods have been recommended. Remunerative employment is essential to provide the necessities of life, but unsuitable employment may be instrumental in producing reactivity of the disease with consequent relapse, while unemployment is psychologically and physically incompatible with a normal outlook on life and a sustained resistance to the disease.

The form of employment to which a patient with arrested or quiescent tuberculosis returns after a term of institutional treatment must be suited to his temperamental state and physical condition, otherwise he will tend to relapse. The occupations associated with inorganic dust which predispose to the disease are debarred, while employment which makes too great a demand on physical or mental effort is unsuitable. Heaf emphasizes the importance in after-care schemes of ensuring that patients are free from anxiety and physical overstrain. Associated with the question of employment is that of adequate nourishment. The importance of nutritional resistance as a defence against clinical tuberculosis has been previously referred to, and such resistance must be specially conserved, in the case of the patient who is employed, as a protection against relapse. The patient who has little reserve of resistance against reactivity of the disease will certainly relapse if his standard of nutrition is impaired from lack of food, or if the disease is reactivated by too excessive muscular effort or by continued physical or mental strain.

In considering the question of employment in relation to the tuberculous patient it is necessary that it should be viewed as a threefold problem, namely, in regard to the capacity to return to

normal industrial life, to the necessity for non-residential sheltered employment and to the provision of residential sheltered employment. Brieger divides patients in relation to employment into four groups, namely (*a*) those employed in the open labour market, (*b*) those undergoing training, (*c*) those in temporary sheltered employment, and (*d*) those in industrial settlements.

The first step in the training and employment of tuberculous patients takes place in the sanatorium and constitutes what is now termed occupational therapy. The grading of patients' work under strict medical supervision enables gradual progress to be made in the patients' working capacity *pari passu* with improvement in health, and it lessens the risk of relapse from overstrain. A colony may be attached to or be associated with the sanatorium to which patients who are regarded as suitable, both physically and temperamentally, may be transferred. In some sanatoria the colony principle is adopted by providing special accommodation for the occupation of ex-patients who are employed on work connected with the sanatorium for which a small wage is paid. In connexion with some of the Welsh Sanatoria cottages are provided for the training of female patients in housework. Examples of colonies associated with sanatoria are Wrenbury Hall Colony, Cheshire, the chief industries of which are poultry-farming and carpentry, and the Hairmyres Colony in Scotland, which provides a sanatorium of 250 beds, and training and employment in an industrial section for about fifty patients.

The urban workshop has been tried as a non-residential training centre for ex-patients. In London the Spero workshops provide occupations for patients who have previously had some training in leather handicrafts; leatherwork and glove-making being the industries in which the ex-patients are now employed. The average number of patients employed is twenty-eight, and the turnover represents about £2,000 per annum. Bardswell has stated that these workshops are an attempt to run a business on commercial lines and at the same time to pay the trade rate of wages, and that within certain limitations they are an encouraging success.

An urban workshop which has successfully operated for some years is the Altro workshop of New York, which admits patients who are only partially fit for a full day's work, but in the majority

of whom the prognosis is favourable. The patient and his family are under adequate supervision and special treatment is provided. The workshop manufactures washable articles and uniforms for hospitals, institutions, and industrial and commercial firms, and the number of workers employed is between 125 and 135. The wages are trade rate wages and the working time is restricted to thirty-six hours per week; this necessitates extra payment by means of subsidies. The further development of this workshop provides for the accommodation of unmarried workers in suitable quarters in its vicinity. There are workshops organized on similar lines both in this country and in America, but while they serve a very useful purpose and do excellent work, they do not develop to any great extent, and consequently the ex-patients who benefit under this system of sheltered occupation are restricted to a comparatively small number.

The aim of urban workshops, as pointed out by Brieger, is to provide non-institutional after-care, and although they do not provide dwelling accommodation they are associated with supervision of the family as a unit. They constitute a useful method of providing employment suitable to the capacity of the ex-patient, a factor which is of value in preventing overstrain and in maintaining the relative measure of health which has resulted from treatment.

A further method of non-residential employment for ex-patients is provided by handicraft classes, a number of which have been established in London; at these classes the average number of patients attending is usually twelve, which is relatively small. At two of the classes instruction in cooking and in the purchasing of food to the best possible advantage is also given to female patients, and to the wives and mothers of patients. This additional instruction is of special advantage in relation to after-care, as it assists by means of improved feeding in maintaining health and resistance.

The residential employment of patients associated with concurrent treatment is typified in this country by such institutions as the Papworth Village Settlement, Preston Hall British Legion Village, and Barrowmore Hall Sanatorium and Settlement.

This type of institution has been termed the Village Settlement and has been defined by the Ministry of Health as follows: 'The

Village Settlement consists essentially of a hospital-sanatorium which treats patients in nearly all stages of the disease, with the establishment of an industrial section in association with it, a section where the treatment can be prolonged and training in a suitable calling can be begun. The Village Settlement gives permanent employment under good hygienic conditions in a variety of trades and pays trade union wages to its skilled workers, and in this way it forms a village community, in which work at an industry is combined with country life. It cannot cure every case of tuberculosis, but can lengthen the life of the majority of cases.' Brieger has estimated the cost of a village settlement, established near or in connexion with an existing sanatorium for 500 patients, to be approximately £100,000.

The Papworth Village Settlement came into existence in 1915, the aim of its founders being to make the tuberculous patient capable of full-time normal employment with the capacity to earn full wages, or where that was impossible to conserve and to increase the relative capacity for work by suitable employment under sheltered conditions. The Settlement does not aim at providing permanent sheltered occupation for arrested cases, but is primarily intended for the colonization of sputum positive cases, or those who suffer from repeated relapses.

The Settlement is a composite institution which provides hospital accommodation for advanced cases, sanatorium accommodation, training in the industrial section, and settlements in the village. A patient may thus graduate from the hospital to final establishment in the village as a settler.

The Settlement provides various special departments which are necessary in relation to the diagnosis, treatment, and investigation of the disease; these include the Department of Radiology, the Surgical Unit, the Dental Department, the Pathological and Bacteriological Department, the Biochemical Department, and the Department for Clinical and Industrial Physiology. In addition, ante-natal, ear, nose, and throat, ophthalmic and orthopaedic units are provided, so that every facility exists for the modern treatment of the disease and its complications. Brieger summarizes the provision made at Papworth as follows: 'the multiplicity of the initial material received makes it necessary for Papworth to cater for all types of cases—medical treatment,

occupational treatment, temporary occupational after-care, occupational after-care of indefinite duration, hospital treatment, and, finally, colonization with permanent sheltered employment, all are provided.'

The comprehensive character of the employment in which patients at Papworth are engaged is shown by the following industries which are carried out in the institution:—gardening, carpentry, cabinet-making, boot-repairing, poultry-farming, tailoring, printing, trunk-making, sign-writing, upholstery, and building construction.

The main principles upon which the establishment and administration of Papworth Village Settlement are based have been enunciated by Sir Pendrill Varrier-Jones and are briefly as follows: (1) It is useless to treat a tuberculous patient without reference to his economic situation. (2) The family, and not the patient alone, is the unit to be dealt with. (3) Tuberculosis is a fluctuating disease and middle or advanced cases are permanently sub-standard. (4) Permanent after-care, in circumstances enabling good wages to be earned and normal family life to be resumed is essential for those who are rendered permanently sub-standard by the disease. (5) Every position from that of the general manager downwards must be open to a disabled man or woman. (6) Each industrial department should be built around a personality. (7) No visible element of charity must enter into the industrial departments. (8) Hours of work must be prescribed by a medical man who must satisfy himself by physiological tests in each individual case, but not otherwise intervene in industrial matters. (9) Industries should not be expected to bear the cost of interest and amortization of capital. (10) Sales must govern production, since it is disastrous to manufacture what will not sell. (11) Machinery compensates disability—therefore mechanize to the maximum. These principles indicate to what extent the success of the conception of the industrial and village settlement depends upon the association of modern methods of treatment and supervision, with business acumen, personal influence, and the ability to gauge the economic value of the relative or full working capacity of the patient.

Preston Hall or the British Legion Village is also an institution which embodies the main principles of modern treatment,

industrial training and after-care, and the village settlement. It was established in 1920, and in 1925 it was reorganized and remodelled on the lines prevailing at Papworth.

The village is a comprehensive unit which includes provision for the most modern methods of diagnosis and treatment. In this connexion McDougall states: 'Not only has Preston Hall become a recognized centre for the routine treatment of individual cases, but it has become a specialized centre where the most up-to-date methods of diagnosis and treatment are available for all patients. It requires some years of work in a village settlement to appreciate how difficult it is in a number of cases to keep men suffering from pulmonary tuberculosis in reasonable health when all the attributes of diagnosis and treatment are at hand and where medical supervision is perpetual. How much more difficult it would be—and the available statistics prove it—to avoid relapses when nothing but medical resources are available.'

The main sections at Preston Hall are the sanatorium, the industrial section, the village settlement, and the convalescent annexe at Douglas House, Bournemouth. In addition, there are special units, chief of which are the surgical and radiological units. During the two years ending September 30th, 1937, there were 1,237 patients admitted to the sanatorium section, and of the total number admitted 888 were ex-servicemen. The surgical unit provides an important part of the treatment for selected cases at Preston Hall, and during the period of two years under review 175 operations were performed. McDougall in describing the work of this section refers to one important point, the implication of which should be more widely appreciated; he states: 'We are anxious to produce collapse of the lung substance in one way or another, by limiting the amount of trauma which occurs during the operation itself, for so many patients, when they reach the stage at which operation becomes essential, are in such poor general condition that the more extensive operations involve risk.'

In the radiological section special attention has been directed to tomography and during recent years a routine investigation of cavities in the lungs by means of the tomograph has been carried out. Attention is now being directed to a special investigation of sputum positive cases with minimal signs shown by ordinary radiological examination to determine to what extent

further light is shed on the radiological picture by means of the tomograph.

In the industral section at Preston Hall the following industries are maintained: the manufacture of portable buildings, graining, printing, and the manufacture of fancy goods, while ex-patients and patients are also employed in gardening and farming and in the management of the estate and institution.

One feature of the scheme at Preston Hall which has been adopted is to discharge from the village settlement patients with arrested disease in whom there is no evidence of clinical tuberculosis, and to arrange for them to live elsewhere, thus releasing accommodation for definite clinical cases. McDougall states that there is no justification for keeping cases with arrested disease for five consecutive years in the sheltered conditions of a village settlement, and in this connexion he points out that in the great majority of cases of pulmonary tuberculosis which, during a period of five years have shown no signs or symptoms of active tuberculosis, the liability to relapse is very slight. He quotes the ratio of recovered cases removed from, and restored again to, the dispensary registers for Lancashire and the London County Council area for specified periods as 3·8 per cent and 3·9 per cent respectively.

A settlement on a smaller scale than Papworth and Preston Hall is the Barrowmore Hall Sanatorium and Settlement in Cheshire. The total number of settlers, staff, and patients, in 1935 was 254. The industries provided include carpentry, upholstery, printing, boot-repairing, poultry-rearing, and gardening.

In Ireland the Peamount Sanatorium Industrial Colony has been developed on the Papworth model. Its chief industries are the construction of portable buildings and glove-making, the latter being adopted for the employment of female patients. The colony is under the management of an ex-patient from Papworth.

The Burrow Hill Sanatorium Colony at Frimley, which has been established by the National Association for the Prevention of Tuberculosis, provides treatment and training for a special group of patients, namely young adolescent males between the ages of fourteen and twenty; there is accommodation for eighty colonists. Instruction is given in gardening and clerical work, and there is also a course in general education which includes

such subjects as English, History, Arithmetic, and Economic Geography. It is interesting to note that arrangements exist with the London County Council by which the Parks Department allots five vacancies every year to young men from the colony who fulfil necessary qualifications. The good results obtained in the colony are indicated by the fact that about 60 per cent of the colonists who have completed training are in full-time work.

Training in settlements for tuberculosis patients have also been established in France, notably at the Bligny Sanatorium and the Health Village at Salagnac, and in the United States, examples of which are the Endowood Farm Colony, the Olive View Sanatorium Camp, and the Central New England Scheme at Rutland.

Special provision for the training of young males between the ages of sixteen and twenty-two who have been crippled by non-pulmonary tuberculosis is made at the Cripples' Training College connected with the country branch of the Royal National Orthopaedic Hospital at Stanmore; the college is approved by the Board of Education for grant purposes. The course of training covers a period of three or more years with a minimum of three according to the student's ability. The trades taught include book-making, upholstery, painting and sign-writing, woodwork and cabinet-making, tailoring, watch- and clock-making, and commercial training. The workshops are constructed on the most approved hygienic lines and facilities for indoor and outdoor recreation are provided. All trainees have to attend school for general education for one hour each day in accordance with the regulations of the Board of Education.

A study of the solution of the problem of the after-care of the tuberculous patient by means of the colony and village settlement cannot but impress one that it is based on sound and correct principles. The patients' capacity for work is gauged by close observation and physiological tests, so that the physical effort required for his employment is commensurate with his physical capacity. He lives under conditions of rural life, away from possible contact with overcrowding and vitiated air, while his intake of food in quantity and quality is adequate to sustain the balance of resistance against the disease. Moreover, his life is so

ordered and supervised that early evidence of relapse from recrudescence is detected, while every modern method of treatment is available. In a word, he is living both sociologically and clinically under the best possible conditions. If one were to criticize the colony and settlement scheme it would be from the point of view that, as at present provided, it touches but the fringe of the problem, and that something more in the field of treatment is called for if more speedy and more permanent results are to be obtained. The very essence of the scheme, namely permanent sheltered occupation for sputum positive cases, restricts the number of patients who can be dealt with.

The question is frequently asked: Can the principles so successfully embodied at Papworth and Preston Hall be applied to other districts in a manner to justify the cost involved? It will be appreciated that there is a difference between the scope and possible development of an institution of this character when administered on voluntary lines as compared with one which is exclusively rate aided. The view of the Ministry of Health is that the development of the colony and village settlement scheme on something approaching national lines can only be approached by the co-operation of several authorities in different parts of the country. A preliminary step towards this would obviously have to be a survey of the country as a whole, so as to divide it into areas, each of which would be geographically suited for a colony and settlement. Consideration would also have to be given to the ratio of the tuberculous population which could be served, and to the existing facilities for quick disposal of articles produced. The haphazard development of colonies and village settlements without any approach to a general comprehensive scheme for the country as a whole would not meet the problem.

The chief difficulty to be faced in regard to a national scheme of village settlements, apart from the question of finance, is that in the case of those patients who graduate through the various departments up to the stage of arrest or quiescence and full working capacity, a protracted or permanent residence is necessary if unemployment with its injurious effects is to be avoided. This militates against the possibility of dealing with any large proportion of cases. At Preston Hall the 'arrested case scheme' has been adopted to ease the position, but this can only do so to a

minor degree. The possibility of amplifying the scheme so as to be able to draft suitable cases to suitable employment should, however, be further explored. This would require the institution of an employment bureau as the final unit of the scheme to secure a continuity of sanatorium, hospital, industrial colony, village settlement, and employment bureau. To attempt such a scheme would only be possible with Government assistance, not only as regards finance but in relation to outlets for employment.

Heaf has recommended the establishment of a National Board to control the rehabilitation of tuberculous patients. He suggests that the Board should be formed by representatives of existing associations interested in tuberculosis, be established on a voluntary basis, and be supported by contributions from the State. Its main function would be to advise and assist all local authorities in matters relating to rehabilitation.

Chapter Ten

TUBERCULOSIS AND THE NURSING SERVICE

THE nursing of tuberculous patients is becoming increasingly a specialized service which is essential to the successful treatment of the disease. The variation in type which the disease presents calls for variation in the duties of the nurse; in the acute and advanced types of the disease her duties partake of actual sick nursing, frequently of a very exacting character, while in the ambulant type of case her duties which are no less responsible include tactful supervision, encouragement to persevere, and attention to routine. In regard to certain forms of treatment, such as the surgical treatment of pulmonary tuberculosis and the conservative treatment of tuberculosis of bones and joints, special experience on the part of the nurse is called for. It is necessary also that the tuberculosis nurse should have regard to the psychological and sociological aspects of the disease. She is called upon to encourage the depressed patient and to control the nervous and excitable type of patient, with a view to inducing them to take a controlled and rational outlook on life and to co-operate in carrying out measures of prevention and treatment.

The preventive aspect of the nursing of cases of tuberculosis is one to which the nurse must give intelligent and sustained attention. Not only is this necessary with a view to preventing the infection of relatives and others who are contacts, but it is of equal importance in relation to the nurse herself, especially when she is in daily and intimate contact with open cases of the disease.

TRAINING OF TUBERCULOSIS NURSES. In the training of the nurse for the tuberculosis service due consideration must be given to the varied character of the duties she will be called upon to perform. The special experience required is obtained by a period of not less than three months training at a sanatorium, tuberculosis hospital, or tuberculosis dispensary. In addition, the tuberculosis visitor or nurse

must be a fully trained nurse or hold a Health Visitor's qualification.

As the duties of the tuberculosis nurse relate to the tuberculous patient under separate and different circumstances, it is desirable that she should be instructed as to character and extent to which her duties will be varied by these conditions. Of special importance is instruction in the duties the nurse will be called upon to perform and the difficulties she will have to face in connexion with domiciliary nursing, and in the practical application of preventive measures in the home. In this connexion post-certificate instruction is of value as a means of maintaining an efficient standard, especially in relation to preventive action.

Apart from such knowledge as she has acquired during training as a general nurse or for her health visitor's certificate, a tuberculosis nurse or visitor should receive special instruction in the causation, symptoms, treatment, and nursing of tuberculosis, due emphasis being laid upon its relationship to social conditions. She should also be instructed regarding the various points at which contact can be made between the tuberculosis service and other Public Health services, and in the aetiological relationship which overcrowded housing conditions and inadequate nourishment bear to the disease. A point of importance in training is assessing and reporting upon housing conditions. The actual training in the nursing of tuberculous patients should take cognizance of the difference between institutional nursing and domiciliary nursing, and of the value of suggestions to overcome the difficulties associated with the latter. Throughout the training emphasis must be placed on the variable degrees of risk which arise at different stages in the patient's life, and the practical measures which can be adopted to minimize such risk.

PROTECTION OF NURSES. Reference has been made in a previous chapter to the incidence of tuberculous infection among nurses. Although there exists no evidence of a high rate of incidence of the disease among nurses in tuberculosis hospitals and sanatoria in this country, it is necessary that certain precautionary measures should be adopted to protect them from clinical infection. These measures relate both to the patient and

to the nurse herself. Where an efficient and sustained standard of practice in regard to the destruction of sputum and infected material and to hygienic precautions in the hospital or sanatorium is carried out, the risk of infection to the nurse sufficient to give rise to clinical manifestations of the disease is very slight indeed, although repeated infection with minimal doses will undoubtedly occur. Geer and Heimbeck have shown that most of the nurses who have developed tuberculosis have been negative to tuberculin when taking up the duty of nursing tuberculous patients. It would appear, therefore, to be desirable for purposes of protection that a nurse who is taking up the duty of nursing tuberculous patients should give a positive reaction to tuberculin although presenting no slightest evidence of clinical infection.

The following measures to be adopted for the protection of nurses who are in contact with open cases of tuberculosis are based on the recommendations of the Joint Tuberculosis Council.

The first and most important precautions relate to the patient and the medium through which tubercle bacilli are expelled, the *fons et origo* of infection. The disposal of sputum and other infected material by boiling or incineration is an essential precaution, and the method of sputum disposal adopted in tuberculosis institutions should be under frequent inspection and its importance continually emphasized. Careful and sustained attention must also be given to the collecting and disposal of infected handkerchiefs, linen, and other material, and to the cleansing and disinfection of crockery and cutlery, and of nursing utensils. As a further protection for nurses it is essential that a high standard of cleanliness in the wards should be maintained, with adequate circulation of air and freedom from dust and litter.

The general health and resistance of the nursing staff must be maintained at a high level. Attention must be given to the hours on duty and the time required for study, with a view to avoiding physical and mental overstrain. It is now generally agreed that as regards hours on duty the aim should be to provide a service of forty-eight hours per week or ninety-six hours a fortnight. Importance must also be attached to adequate and regular feeding,

hours off duty, and facilities for rest and recreation. The question of the absence or presence of specific resistance in the case of probationers is one which should be considered; it is desirable that every probationer who is taking up the duty of attendance on open cases of tuberculosis should be tuberculin positive. Negative cases, if accepted, must be introduced gradually to contact with the open cases of the disease, and special efforts must be made to maintain an adequate standard of nutrition and resistance.

The memorandum of the Joint Tuberculosis Council recommends that no probationer should be accepted for work in pulmonary tuberculosis wards under the age of eighteen, that in addition to a clinical examination every nurse should have a chest skiagram on entry, to be repeated annually in the case of nurses dealing with open cases of the disease, and that in tuberculosis institutions the monthly weighing of nurses should be carried out, the weight records to be seen regularly by a senior medical officer. As regards the uniform of the nurses, the wearing of ward overalls which can be left behind in a changing-room is recommended, and although the wearing of masks is not generally considered necessary, it is essential that where the duties of the nurse call for close contact with and attention to special cases, e.g. patients with laryngeal tuberculosis, they should be worn. Geer has found that the adoption of a strict antiseptic technique which involved, *inter alia*, the wearing of masks, head-caps, and overalls, has resulted in a lower incidence of clinical infection. The Council is of opinion that the protective technique adopted in fever hospitals might with advantage be applied to tuberculosis nursing. Instruction in the principles of personal hygiene and in the personal measures which are necessary for protection against droplet and dust infection should be given, and special emphasis should be attached to the importance of washing and disinfecting the hands after attending to patients, on leaving the wards and before meals. The following example of a leaflet of instructions to nurses is given in the appendix to the Council's memorandum:

LEAFLET FOR NURSES
(as used at Cheshire Joint Sanatorium)

Notice

If you adopt strict precautions the danger of contracting any disease is remote. This is particularly true of pulmonary tuberculosis.

1. *Sanatorium routine*—ample air, food, rest, and cleanliness are not only best for treatment, but also for prevention.
   Abundance of air and daylight in sitting-rooms and particularly in bedrooms.
   Abundance of food at regular meal-times.
   Abundance of bed, at least eight hours per night.
   General cleanliness of the body and sufficient exercise.
   If you feel a little tired, rest when off duty, and if tiredness persists, report sick.
   If you fear that you have any symptoms of tuberculosis report at once. Examination will ease your mind.
   Wash your hands thoroughly after handling infectious material and always before leaving the wards.
   Get out of your uniform as soon as you can.
2. *Patients*—Be relentless in enforcing the standing order for sputum and handkerchief disposal.
   There is danger in the unseen spray resulting from coughing, loud talking, and laughter.
   Therefore insist upon the patient covering the mouth when coughing, and discourage loud talking and laughter.

DISPENSARY NURSING. The duties of the nurse in connexion with the tuberculosis clinic relate to both the clinic itself and to the home of the patient, and may be carried out by a whole-time tuberculosis nurse or by a district nurse. In large urban districts the work of the dispensary nurse is concerned with the clinic only, as the administrative, clinical, and clerical duties at clinics which serve as centres of anti-tuberculosis activities in cities and large towns require whole-time service. At the clinic the duties of the nurse include preparing patients for examination, taking temperatures, weighing patients, and keeping registers. She also assists in the application of diagnostic tests

and in carrying out of special forms of treatment. One important duty for which the nurse is responsible is to supervise the cleanliness and ventilation of the clinic, and to see that facilities for the collection and destruction of the sputum and infected material are efficiently provided and maintained. The nurse has also the opportunity of advising and instructing the patient in matters relating to his own health and to the prevention of infection in the home. One important duty in this latter connexion is to persuade and arrange for contacts to present themselves for examination at the clinic. By the use of tactful persuasion and by simple explanation as to the preventive necessity for such examination the objections which may be raised can frequently be overruled by an intelligent nurse.

Apart from efforts at securing the routine examination of contacts the nurse should in her association with existing cases of the disease be on the outlook for suspected cases or undetected clinical cases, as, for instance, a person with hoarseness of voice or who has a chronic cough. This requires the development and constant use of her powers of observation and knowledge of the family history. The object of this is to facilitate the detection of early or masked cases of clinical infection. The co-ordination of dispensary duties with supervision of the family unit is more difficult to carry out in rural districts. Patients who visit a rural clinic may come from a district which is served by a nurse who has no connexion with the clinic. To secure necessary co-ordination it is important to get into touch with the nurse of the district in which the patient resides through the medium of the central office or clinic.

NURSING IN HOSPITAL AND SANATORIUM. The standard of nursing in institutions for the treatment of tuberculosis approaches that of a specialized service. The development within recent years of more radical forms of treatment and the evolution of the sanatorium along hospital lines have necessitated the employment of a trained and more experienced personnel. The nursing service in the hospital sanatorium has, therefore, to be organized on hospital lines with a sister responsible for a recognized number of patients and having under her staff nurses and assistant nurses; an adequate night staff according to the number of patients is also essential.

The actual duties of the nurse vary according to the type and form of the disease from which the patient suffers. In the case of ambulant patients who are up all day, one of the principal duties of the nurse is to see that the patient adheres to the rules and regulations which have been laid down. This calls for the exercise of discipline and tactful firmness, as no efficient standard of treatment is possible in the presence of laxity and indifference to restrictions and precautions. Attention to detail and ordered routine constitutes a most important part of the treatment of a disease in which resistance and progressive activity are frequently so delicately balanced. It is for this reason that careful attention has to be given by the nurse to the daily life of the patient during treatment, more especially in regard to temperature and weight records, hours of rest, exercise, recreation, food, sleep, and the control of coughing. In the hospital unit where accommodation is provided for acute cases and in the unit where advanced and incurable cases are accommodated, the duties of the nurse partake of a definite nursing character.

The acute case of recent onset requires special nursing attention; strict rest, suitable and adequate dieting, control of cough, measures to reduce fever, and the general comfort of the patient, all call for careful attention. The advanced case with progressive asthenia becomes very helpless and requires palliative and preventive measures in the carrying out of which the services of an experienced and intelligent nurse are essential. The prevention of bedsores, assistance in the use of the sputum mug, assistance in feeding, the promotion of cleanliness, and the lessening of pain and discomfort all demand sympathetic attention; and in all stages of the disease the service of the nurse are necessary to ensure adequate measures to minimize the risk of infection by securing the collection and destruction or sterilization of all infected material. The medical superintendent or medical officer of a hospital or sanatorium may issue adequate instructions as to the measures to be adopted in the ward to prevent infection, but it is upon the nurse that the responsibility rests to see that these measures are efficiently maintained in practice. In certain hospital departments special experience is required of the nurse. In surgical units in which the modern surgical treatment of pulmonary tuberculosis is carried out, a nursing staff familiar with the nursing

care which such cases require constitutes an essential part of the personnel of the unit. In hospitals also which provide the modern methods of treatment of non-pulmonary tuberculosis, a nursing staff with special experience is necessary. Heliotherapy and immobilization, more especially the immobilization as applied to young children, call for experience and special care and attention. Experience and special attention are also required in the nursing of tuberculosis of special organs and structures such as the eye, the larynx, the pharynx, the skin, the kidney and the meninges.

DOMICILIARY NURSING. This includes the domiciliary visits made by the tuberculosis visitor, chiefly with the view to preventive action, and the actual nursing of tuberculous patients in their homes. The duties of the nurse in relation to domiciliary nursing is threefold, namely, to give council and guidance to the patient in matters relating to treatment and after-care, to emphasize the importance of, and to supervise the continued application of preventive measures in the home, and to give nursing attention to patients confined to bed. The nurse acts as the 'liaison' officer who links up the patient in his home with the tuberculosis clinic, and as such she is in a position to exercise much influence for good in relation to treatment and after-care. But it is in the field of prevention more than in any other direction that the nurse during her visits to the home will find her greatest scope for usefulness. An intelligent nurse who appreciates the risks to which contacts are exposed and who is alive to the importance of the practical measures which can be taken to lessen such risk, can exercise a real influence on the incidence of clinical infection. Part of the duties of the tuberculosis visitor is to study and report on the conditions in the home, and to bring to the notice of the authorities concerned conditions which require to be remedied, or circumstances which call for immediate action. She must view the home not only in relation to the care and comfort of the patient himself but also in relation to the security and protection of the other members of the family. The circumstances of the family and the conditions under which they live must, therefore, be her constant concern.

This same dual responsibility devolves in special measure upon the nurse who is engaged in the actual nursing of a tuberculosis patient who is confined to bed in his home. Whether she be a

private nurse or the nurse who makes periodical visits, her first duty will be the care and nursing of her patient in regard to comfort and remedial and palliative measures. Special attention should be given to careful records of pulse and temperature, advice and directions as to diet, the control of coughing and the cleanliness and ventilation of the room; and in addition to this, the nurse who is carrying out domiciliary nursing must give constant attention and supervision to the efficient carrying out of preventive measures and realize the importance of her duties in this connexion.

It is during the closing stages of the disease that the services of a skilled nurse are most urgently required in domiciliary cases. The progressive asthenia and emaciation, profuse perspiration, difficulty in the expulsion of sputum, incontinence, and threatened pressure sores, call for skilled nursing and care. A stage is reached when the patient becomes too weak to be able to expel the sputum cleanly, and soiling of face, hands, outside of sputum cup, and bedclothes inevitably occurs; this calls for the exercise of special precautionary measures on the part of the nurse and of those in attendance upon the patient.

Chapter Eleven

SUMMARY OF CONCLUSIONS

THE conclusions to be drawn from a study of Tuberculosis and National Health relate to epidemiological factors and clinical problems. The following is a summary of these conclusions.

(1) Tuberculosis is a protean disease which infects man and the lower animals; the organism shows certain characteristic variations according to the selected host.

(2) The character of the relationship of the human type of the tubercle bacillus to the types which infect the lower animals is unknown. It is difficult, however, to explain some aspects of the epidemiology of tuberculosis, except on the assumption that evolutionary mutation from one type of organism to another does take place, although there exists no experimental evidence in support of this view.

(3) Tuberculosis is a disease of crowded communities, the incidence increasing as the social and hygienic standard of such communities deteriorates. Tuberculosis may, therefore, be accepted as an accurate index of the social and health standard of a community.

(4) Tuberculosis is unknown among savage races, especially those who are constantly on the move. Such races are, however, extremely susceptible once infection has been introduced. There is some correlation between fixity of domicile and tuberculosis.

(5) All races are not equally susceptible; dark races are more susceptible than white, and the Celt has less resistance than the Anglo-Saxon.

(6) Apart from inherited or specific protection, resistance to tuberculosis is governed by the standard of nutrition and the degree of local resistance. The standard of nutrition is determined by the quantity and quality of food and by the influence of environmental factors which, operate through the nervous system and the blood-stream. The degree of local resistance may be directly impaired by trauma.

(7) Tuberculosis is a general infection with a primary pulmonary focus in over 80 per cent of cases. The primary pulmonary focus may also be present even when infection is introduced by the intestinal tract. The infection may remain primarily pulmonary in character or become generalized, or give rise to metastatic manifestations in various structures and organs.

(8) Secondary infection may be due to local or metastatic extension of the primary infection, or result from fresh exogenous invasion.

(9) A primary infection which heals imparts a definite measure of specific protection against further infection. A primary infection which does not heal remains latent or continues active and progressive; a latent focus may subsequently become active. A primary focus which does not heal imparts no adequate measure of protection against further infection.

(10) The two primary causes of tuberculosis in the human subject are close contact with an open case of the disease and the ingestion of milk containing bovine tubercle bacilli. Respiratory tuberculosis of bovine origin has been observed in persons who have been in contact with infected animals.

(11) The origin of infection in non-contacts and in certain groups of positive reactors has not yet been fully explained. Contact infection does not quite explain the high incidence of reactors in some groups of the general population.

(12) As the life cycle of the tubercle bacillus and its relationship to the human host are not yet clearly known, it is possible that some other method of infection exists regarding which we have at present no definite knowledge.

(13) The main basis of prevention is to maintain resistance at a protective level, to minimize the risk of infection and to prevent the impairment of local resistance by trauma.

(14) General resistance is maintained by an adequate and balanced intake of food, by good housing and industrial conditions and by the avoidance of physical and mental strain and fatigue.

(15) Local resistance is maintained by the avoidance of injury, excessive physical strain and of pulmonary trauma arising from the inhalation of irritating dust.

(16) Protection against infection with bacilli of human origin

demands the carrying out of certain specific measures, more especially the segregation of advanced cases which are going down-hill and the removal of young contacts from infected homes.

(17) In regard to the segregation of advanced cases, consideration should be given to the more extended provision of local accommodation for such cases.

(18) Protection against infection with tubercle bacilli of bovine origin can only be secured by the elimination of tuberculosis from dairy herds, and until that is attained by the efficient pasteurization of all milk.

(19) One result of the progressive fall in the incidence of clinical tuberculosis is an increase in the ratio of susceptibles; this is a factor to which due importance must be attached in estimating the future incidence of the disease.

(20) The incidence of clinical tuberculosis is increased by any lowering of the resistive capacity of the population; associated with such impairment of resistance there may occur exaltation of virulence in the character of the organism if the ratio of susceptibles is high.

(21) War, especially when prolonged, leads to increase in the incidence of tuberculosis. Resistance is impaired by strain, fatigue, trauma, and interference with the normal supply of food, while the risk of infection is increased by overcrowding, and the mass movements of population.

(22) The early detection of tuberculosis of the lungs before the onset of the stage of progressive caseation is of primary importance in relation to prophylaxis and successful treatment. Contact and group surveys and the routine employment of bacteriological and radiological investigations, in addition to clinical examination, are essential if clinical tuberculosis is to be diagnosed more frequently in its early stages.

(23) The modern treatment of tuberculosis consists of conservative measures supplemented by major and minor operative treatment in selected cases.

(24) The modern methods of treatment, owing to concurrent protective measures, have in part been responsible for the continued decline in the death-rate from the disease, and they are directly responsible for an increased expectation of life. There is

no evidence, however, that there has been any commensurate decline in the case mortality of the disease.

(25) This latter fact, in the light of our knowledge of Koch's phenomenon and of the protective influence of a primary healed infection in the human subject, suggests that it is the field of immunology which must be explored if a method of treatment is to be discovered which will definitely decrease tuberculosis case mortality.

(26) The approach to the investigation of the specific treatment of tuberculosis should be in the direction of producing tuberculin under conditions of growth and toxin elaboration, as nearly as possible similar to those under which tuberculin is produced in the human body, namely a comparable culture medium, including human blood serum.

(27) The sociological aspects of tuberculosis present a problem which can only be successfully solved with State aid and co-operation.

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